PROCEEDINGS

OF THE

ENGINEERS' CLUB

OF

PHILADELPHIA.

(ORGANIZED 1877.)

VOL. I.

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The Club is not responsible, as a body, for the facts and opinions advanced in its publications.

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ILLUSTRATIONS.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

The Engineers' Club of Philadelphia is the outgrowth of a few social gatherings of young gentlemen interested in the several branches of engineering science, who met for conversation and "comparison of notes" during the fall of 1877. The attempt to organize such a club was probably suggested and encouraged by pleasant recollections of the very delightful Thursday evening meetings which were held during 1876, in the rooms of the Centennial Committee of the American Institute of Mining Engineers, at Eleventh and Girard streets.

At the third social meeting, which was held on Dec. 17th, 1877, the club was regularly organized by the unanimous election of the following officers:

President, Prof. L. M. Haupt.
Vice-President, Coleman Sellers, Jr.
Secretary and Treasurer, Chas. E. Billin.

At that meeting the following gentlemen were present: Messrs. C. Sellers, Jr., H. W. Sellers, C. A. Ashburner, E. Nichols, J. F. Robinson, P. H. Hickman, L. M. Haupt, C. E. Billin, P. Roberts, Jr., M. R. Mucklé, Jr., H. Sellers, W. F. Sellers, T. J. Lewis, W. Lewis, O. B. Colton, G. R. Buckman, G. Burnham, Jr., C. A. Young, G. H. Christian, Jr.

A committee was appointed to frame a constitution and by-laws, who reported at the next meeting. The constitution then adopted limited the membership to fifty. Although the constitution was revised by a committee appointed Oct. 5th, so as to meet the growing needs of the Club, the membership could not be increased until after the First Annual Meeting.

This first number of the "Proceedings" contains the principal papers and communications which have been read before the Club during the past year. Though none of them are long theoretical papers, they nevertheless contain much information of very great practical value, and show a degree of activity among Philadelphia engineers which could not have been developed by any other means than informal meetings. Several of the papers relate to engineering problems either in or about the city of Philadelphia, and, as it is intended that the Club shall aid and develope the progress of engineering science in this city as much as possible, it seems most fitting that subjects of local interest should frequently come before the Club for discussion and criticism. If these papers and discussions are confined entirely to meetings of the Club, much of the good which they might, and ought to do, cannot be accomplished. It is hoped, however, that in the future, the Club will be so situated that publications can be made every few weeks. The frequency of such publications will depend largely upon the encouragement received from persons whose business should lead them to give substantial aid toward the promotion of every interest of the Club.

C. E. B.

Jan. 11th, 1879.

I.

THE OIL SANDS OF PENNSYLVANIA.

By CHAS. A. ASHBURNER, Member of the Club.

Read February 16th, 1878.

The recent discussion among the producers, shippers and refiners of the petroleum of Pennsylvania, has attracted the public attention to one of the greatest industries of our State. Many points of interest have developed themselves, during the consideration by our Legislature of the pending "pipe line bill," to permit the running of the crude from the well mouth to the seaboard.

One of the most important questions to the petroleum miner, and one which even the more enlightened of our oil men can answer only in a very vague and uncertain way, is, where is petroleum found? The question is an exceedingly broad one, and involves many considerations which cannot reasonably be noticed within the limits of a brief paper. The origin of petroleum, its connection with the sand in which it is found, the influence of the character of the oil sands on their productiveness, the relation of the surface rocks to the oil sands, and the bearing of surface indications upon the position of underlying oil belts, the connection between petroleum and natural gas, etc., are all vital questions which must be met before we can say where petroleum is found and where we may locate profitable wells.

I do not wish to anticipate any of the conclusions which our present Geological Survey may advance, to meet any or all of these questions which suggest themselves so pertinently to those interested in the petroleum industry, or express any views on the more important and practical question as to the position of producing territory, and the location of profitable wells. I have thought it would be of interest to the members of the Engineers'

Club, to give, in a general way, a vertical section of the rock formations, showing the relative position of all the oil horizons of Western Pennsylvania, together with an estimate of the daily production of each horizon.

The portion of the State in which petroleum has been found, lies entirely west of a line drawn across the State, from the State line at the southeastern corner of Greene County to the State line at the northeastern corner of McKean County.

For convenience of description, the oil regions may be divided into three groups or districts—the southwestern, the western and the northern.

The southwestern district may be said to include that part of the State south of the Ohio River and west of the Monongahela River; the western, better known among the producers as the "lower country," lies in the water-basin of the Alleghany River, between Pittsburg, on the south, and the Philadelphia and Erie Railroad, on the north; and the third, or northern district, lies entirely north of the Philadelphia and Erie Railroad, in the counties of Warren and McKean, and extends ten miles into the State of New York.

The strata of Western Pennsylvania lie comparatively horizontal. The average dip of the rock from Bradford, near the State line, to Pittsburg, is about 18 ft. to the mile; that is, a rock which occurs at water level at Bradford, at an elevation of 1450 ft. above ocean level, would be found at Pittsburg about 750 ft. below the same datum, or 1500 ft. below water level.

Three thousand feet of the stratified rocks of the Carboniferous and Devonian Ages in Pennsylvania, have been found to contain petroleum. The highest stratum in which oil is found, occurs in the coal measures, 165 ft. below the Pittsburg coal seam, in Greene county; while the lowest occurs about 3200 ft. below the geological position of the Pittsburg coal seam in McKean county.

If we should drill a well in Greene county 3200 ft. deep, starting on the Pittsburg coal, we would pass through the horizon of all the sands and sandstones in which the petroleum of our State has been found.

This estimate is made on the assumption, that if the coal meas-

ures up to the Pittsburg seam should be restored in McKean county, the lowest oil-bearing rock in the northern district would be found the same depth below the Pittsburg coal, as the geological horizon of the same sand would be found below the same coal-bed in Greene county.

From observations in the western part of the State, we know that the rocks are subject to very marked and rapid changes in their thicknesses, in comparatively short distances. What the change in rock thickness may prove to be, between McKean and Greene counties, we have not sufficient facts at hand to assert. Whether the total thickness of the stratified rocks between the Pittsburg coal and the "Smethport"[1] or lowest oil horizon, at localities between the two counties, shall be found to be a variable quantity, or much greater or much less than the above estimate, the fact, in itself, will not defeat the object of this paper, which is intended to point out the relative, and not the absolute, position of the oil sands one to another.

The petroleum, in the southwestern district, comes from the highest rocks; that in the northern comes from the lowest; while the producing sands of the western district are found intermediate between the other two groups of rocks.

The southwestern district "oil-sand group" is about 800 feet thick, and it is composed of three sandstone members, separated by intervals containing coal seams, slate and shale. The following is a general section of the group, by Prof. Stevenson:

1. Morgantown Sandstone, Dunkard Creek; thickness, 66 ft.

Lower Barren Coal Measures, shales and slates; thickness, 194 ft.

2. Mahoning Sandstone, Dunkard, Whiteley and Dunlap's Creeks; thickness, 50 ft.

Lower Productive Coal Measures; thickness, 85 ft.

3. Piedmont Sandstone and Coal Conglomerate, Dunkard Creek; thickness, 400 ft.

The first or upper oil sandstone shows considerable variation,

[1] This horizon I originally called Sartwell, and it is so published in the FRANKLIN INSTITUTE JOURNAL for April, 1878. Since then the horizon h[as] proved productive in the vicinity of Smethport, McKean county, and [a] change of name is thought advisable.

and is oftentimes replaced by shale. It is a noticeable fact that in this case the shale contains no oil.

The Mahoning or second sandstone is quite constant in thickness, and is the principal repository of petroleum in the southwestern district. It frequently contains conglomerate layers.

The third or lower sandstone is made up of three members, an upper and lower sandstone member, separated by about 30 to 40 ft. of shale and coal. The upper member is regarded as the oil-bearing rock. The lower member, or Piedmont Sandstone, is the representative of the coal conglomerate or millstone grit. No. XII of the Pennsylvania nomenclature.

Some of the characteristics of this district are quite different from those of the western or northern districts. In drilling, small crevices in the oil sands are of frequent occurrence; and it is a striking fact that the oil is said never to have been found except where a crevice was struck. The producers in this field have considered this fact necessary to the original production of oil itself.

According to Prof. Stevenson, the oil in nowise owes its origin to disturbance of strata, and the only effect of the disturbance has been to provide reservoirs for the oil in the rock already oil-bearing.

Between the bottom of the coal conglomerate, which is the lowest member of the lowest oil-producing sandstone of the southwestern district, and the "first oil sand," which is the highest producing sandstone of the western district, there is an interval of from 650 to 700 ft. of shales and sandstones, forming the Barren Oil Measures, or Mountain Sand group. These rocks are perfectly barren of any economical strata; they contain no coal, iron or oil. In Butler county this group often contains gas.

The Greene county "oil sand group," and the upper part of the Barren Oil Measures, belong to the Carboniferous Age, while the oil sands of the western and northern districts are Devonian rocks.

The following is a general section of the oil sands of the western district:

First sand, . . .	40 ft. thick.
Interval, . .	105 ft.
Second sand, . . .	25 ft. thick.
Interval, . .	110 ft.
Third sand, . . .	35 ft. thick.
Total thickness of the group, .	315 ft.

All the oil from Clarion, Butler and Venango counties, which comprise our most productive field, comes from this group, and from one of the representatives of the three sands. These sands are sometimes split up into several members, giving rise to what are known as the "fourth," "fifth" and "sixth" sands of Oil Creek.

The first sand produces a heavy lubricating oil from 30° to 35° gravity; the second, an oil of about 40° gravity; and the third sand, the usual light oil, from 45° to 50° gravity.

The third sand of this district is the most productive, and supplies most of the oil of commerce. According to Mr. Carll, Assistant in the Oil Regions, "the well records along the 'green oil belt' in Venango county, show a great uniformity in the arrangement of the sand rocks. They are sharply defined, massive, and lie at regular intervals. Going southeast from this belt, they gradually split into several members, fine down in their composition, and shade away into shales. Going to the northwest, the third sand terminates rather abruptly—the second sand overlaps it, and continues a mile or two farther; the first sand overlaps the second, and extends, in some places, a long distance beyond. The majority of the wells producing from the first and second sands, are located along these overlapping edges of the sand rocks."

"Wherever the third or lowest sand is adapted to the production of oil, the main deposit is found in it, and not in the sands above. The first and second sands, although of good quality, do not produce oil along the centre of the belt. In some wells, it is true, oil has been obtained from all three of the sands. These wells are not on the axis, but near the edge of the third sand; and but a short distance further from the centre, no third sand can be found."

These are very suggestive facts, and seem to point to the conclusion that the oil sands are merely reservoirs, which have acted as sponges in absorbing the oil which has ascended from a much greater depth. The oil in this case would not be indigenous to the rock in which it is found.

If indigenous, why is the bulk of the "first sand oil" found in the edges of the first sand which overlap or extend beyond the edges of the second and third sands? The same question suggests itself in regard to the most productive portions of the second sand.

Between the "third oil sand" of the western district and the Warren sand of the northern district, there is an interval of about 600 ft. of shale, which is entirely barren. The Warren oil sand is very irregular in character, and the oil is found at horizons varying from 600 to 800 ft. below the Venango third sand.

The oil obtained from the Warren horizon resembles very much the "third sand oil."

Among many of the producers the oil is known as "slush oil," on account of the irregular and poor quality of the sand, and the rapid diminution in the production of the wells, which are large producers when first struck.

The productive horizon of the Bradford oil belt in McKean County and Cattaraugus County, New York, occurs probably 300 ft., more or less, below the Warren horizon. The sand in the Bradford belt is finer and closer in texture than that of any other producing belt in Pennsylvania; it is also more constant in character over a wide area. These facts have much to do with the small percentage of risk which the producer experiences in obtaining "dry holes," or non-producing wells. The Bradford belt is the surest and safest territory in which to operate.

Of the wells completed in November in the Butler, Parker and Clarion districts, 14·8 per cent. were "dry holes"; while in the Bradford district only 6·6 per cent. were "dry holes." This is more than the usual monthly average of "dry holes" in Bradford, on account of the great number of "wild-cat" or test wells which were drilled.

The oil is of about the same gravity as the "third sand oil," but somewhat different in character. On account of the differ-

ence in the sand and in the oil, the Bradford wells are never pumped continuously, but "by heads," or at regular intervals. This is found necessary, in order to keep the sand open and porous. When the interstices of the sand become "choked' by the heavier parts of the oil, the sand is broken up and loosened by nitro-glycerine torpedoes, which are lowered to the depth of the producing sand and exploded.

A great deal of the oil obtained from the Bradford belt, along the State line, is found several hundred feet above the regular producing sand. The horizon of this oil may prove to be the same as the horizon of the Warren oil.

The lowest oil found in the northern district, and, in fact, in Pennsylvania, comes from what I have called the "Smethport[1] oil sand," which has but recently been discovered in Keating Township, McKean County. This horizon is, probably, 350 ft. below the Bradford sand; it has not as yet been thoroughly tested; at present it is non-productive.

Petroleum has never been found in the three groups of oil measures in the same locality. As the oil sands of the southwestern and western district outcrop, or come to the surface, in the northern district, we may never expect to find oil in them north of the Philadelphia and Erie Railroad. The question as to whether we will ever find the northern district oil in the western district, and the oil of both of these districts in the southwestern district, is a very suggestive one. If our future explorations shall prove such to be the case, we are safe in the assertion that, at the present price of crude oil, the wells would be too deep and too expensive to warrant the development.

Production.

I am unable to state how much petroleum is produced in the southwestern district. Quite extensive developments were made in Greene county last fall, and I am informed, on good authority, that one of the new wells was producing 50 barrels a day. No oil territory has yet been found in Washington county.

[1] The Haskill well at Smethport is at present (Dec. 27, 1878) producing about 2 bbls. of oil a day from this horizon. The total production to date amounts to about 500 bbls.

The following table shows the production in the western district, in November last:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Name of Districts.	No. of bbls. of oil produced in the month.	Average per day for the month of 30 days.	No. of wells producing.	No. of wells drilling.	No. of wells completed in November.	Aggregate daily production of new wells.	Daily Average of new wells.	No. of Rigs building.	Dry holes in Nov.
Butler, Parker, Clarion,	709170	23639	4470	275	209	2617	12½	159	31
Scrubgrass,	120000	4000	275	10	12	162	13½	9	2
Franklin,	12000	400	370	10	6	42	7	7	2
Reno,	3000	100	31	.....	.....	......	.....	.....	...
Oil City,	24000	800	365	10	5	32	6½	8	2
Rouseville,	12000	400	200	3	3	21	7	2	1
Rynd Farm,	12000	400	125	2	2	14	7	2	...
Columbia,	3750	125	31	.....	.....	......	.....	.....	...
Petrol'm Cr.	3000	100	50	1	2	10	5	1	1
Shamburg,	6000	200	96	1	2	12	6	1	...
Titusville,	45000	1500	768	10	10	80	8	9	3
Pithole,	6000	200	78	2	2	6	3	2	1
Fagundas,	6000	200	150	1	4	16	4	1	2
Tidioute,	12000	400	83	5	6	42	7	4	2
Beaver,	7500	250	144	12	4	20	5	3	1
Totals,	981420	32714	7236	342	267	......	.....	208	48

The following is the production, for the same month, in the northern district:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Warren,	12000	400	122	5	4	28	7	3	1
Bradford,	180000	6000	965	218	120	1200	10	152	8
Totals,	192000	6400	1087	223	124	......	.....	155	9

The total daily production for November, in the western and northern districts, was 39,114 barrels; in the month of October the same districts produced 40,946 barrels per day. This does not necessarily show a decrease in the actual production; it is probably an error in the estimates.

The above figures were taken from the *Petroleum Reporter*. From reports made to me during the past week, the Warren district is said to be producing nearly 500 barrels, while the Bradford daily production approaches 9500 barrels. Of the Bradford production, about four-fifths come from the regular Bradford sand, and one-fifth from the higher horizons in the "slush oil" wells.

II.

HOUSE AND STREET DRAINAGE OF THE CITY OF PHILADELPHIA.

Abstract of a paper by Rudolph Hering, C. E., Member of Club.

Read March 2d, 1878.

The great importance of a well-regulated and efficient drainage system for houses and streets has only lately been thoroughly understood and appreciated. It is only within the last fifty years, that any successful efforts have been made to free the large cities of the world from the fatal effects of accumulating filth.

Modern medical science has made great progress in discovering the causes of the origin and spread of disease; and it is now well established that typhoid fever, diphtheria, scarlet fever, cholera, and other malarial diseases, are propagated directly or indirectly by decomposing organic matter. The efficient removal of all refuse is therefore very essential for the good health of the City. It is a fact verified by statistics that, where house drains and sewers have been skillfully designed and constructed, a marked decrease of sickness and a reduction of the death rate have resulted. Mr. B. Latham cites twelve cases of cities and towns, with populations ranging from 7,818 to 68,056, and death rates

varying from $19\frac{1}{10}$ to $33\frac{2}{10}$ per 1,000, in which, after the completion of sanitary works, the rate was reduced to from $18\frac{6}{10}$ to $26\frac{2}{10}$ per 1,000, with a diminution in some, of typhoid fever cases, from 10 to 75 per cent. and from 11 to 49 per cent. in cases of phthisis.

As the drainage system of our City is notably bad, it will justify the conclusion, that the occasional prevalence of malarial diseases has probably been due to this cause, and the importance of considering a remedy is therefore apparent.

It is my purpose to give a general idea of the ways in which our houses and streets are drained, and then to point out some of the defects, together with their remedies, which, if not securing a complete immunity from disease, would remove a powerful agency for the evil.

As the subject is one of great magnitude, it will only be possible to point out the main facts, and leave the details for another time.

House Drains.

The *house drains* form the most important part of the drainage system. Upon the care bestowed upon them will, in a great measure, depend the ultimate success of the whole, from a sanitary point of view.

As a rule, they are thoughtlessly designed and carelessly executed: although many of the plumbers, who generally have sole charge of the matter, may be excellent and conscientious workmen, they are generally not versed in the principles of the science governing the design and execution of their work, or are prevented from carrying them out by the unwillingness of the property owner to meet the expense.

Col. Waring has formulated the requirements of a perfect system of house drainage as follows:

Allow no organic decomposition to take place within the dwelling, or within any drain or pipe connected with it under conditions favorable to the propagation of unhealthful influences.

Allow no air that has once been inside of a drain or soil pipe to enter the house under any circumstances.

Let us see how far our house drainage answers this formula. We have in the main three different systems:

First. The drainage of the soil pipe discharges into a cess-pool or well, and the waste waters are conveyed on the surface into the street gutters.

This is the oldest system, and until recently the most used, and is still designed for many new houses built on streets without sewers. In old houses the wells are generally in the cellar; in the new ones they are in the yard. They are lined with bricks, *laid dry*, and, therefore, let the fluids soak away into the adjoining ground.

We, then, *do* allow decomposition to take place in the wells within or near our dwellings, and this under very favorable conditions for spreading disease, and also allow the foul air from the cess-pool, especially when in the cellar, to rise directly into the house.

The surface discharge of waste water is not injurious to health, because it facilitates oxidation. But it is annoying and disagreeable, partly because we see it constantly, partly because it covers the sidewalks with ice in winter and endangers the comfort of pedestrians.

Second. All drainage is conveyed underground to the sewer, including the overflow from the cess-pool.

This system is the most common. The old cess-pool, still used as before, is connected with the sewer generally by an eight-inch terra-cotta pipe. From this a soil pipe, usually of cast-iron, four inches diameter, is carried up to the water-closets. Waste pipes, not over one and a half inch in diameter, run from the kitchen, bath-room and washstands into the soil pipe or main pipe, but generally in a manner which requires the shortest length of pipe, whether this is the best way or not. The spouts are generally carried into the main pipe. Traps are generally put in under each receptacle of refuse, as under each water-closet, sink and washstand. Occasionally an additional main trap is placed where the pipe enters the cellar. The intermediate air-locked portion is then connected with some pipe leading to the roof, generally a rain water spout.

I am told by plumbers that hardly one house in a hundred has its soil pipes ventilated, and much more seldom its waste pipes. No provision is ever made to allow fresh air to enter and

circulate through the pipes. The work itself is generally done very badly, especially in the large number of bonus houses.

It is amazing how recklessly some houses are drained, thus producing and increasing, in reality, the very evil they are intended to avoid.

But let us see the defects clearly by applying our formula. Decomposition is allowed to take place in the cess-pools under conditions favorable to the propagation of unhealthful influences, as the sewage remains there a long time before the overflow carries it away, and the contaminated air, when originating in the cellar, rises immediately into and through the house; or with the well in the yard, it may be carried to the windows by the winds.

The absence of ventilation promotes decomposition in the pipes, and, as the joints and fittings are often poorly made, allowing an escape, the poisonous gas reaches us also directly from this source.

During a heavy rain storm the sewers receive much water; the air is, therefore, forced out, and, as the man-hole covers are tight, it blows out the weakest traps and enters our houses. It can often be detected by the bubbling noise in the washstands and water-closets.

Third. All drainage is conveyed directly into the sewer, solely through pipes, without having any cess-pool on the premises.

This is the latest system and the best. It carries, when properly designed and built, all refuse matter as directly and as rapidly as possible away from the premises.

But the details are the same as before, with the same objectionable features, excepting those of the cess-pool. With the absence of proper ventilation and of a most careful design and execution of all its details, in order to prevent the air inside of the pipes from entering the house under any circumstances, it is impossible to have a system answering the requirements of health.

Why have we these imperfections? Because there is an entire absence of municipal regulations governing the details of house drainage. Proprietors and plumbers have their own way, and carry out their own ideas.

It cannot be doubted that there is as much scientific knowl-

edge necessary for designing and constructing efficient sanitary works as for any other branch of engineering. Therefore, neither the average householder nor the artisan, however skillful he may be, can be expected to properly accomplish the desired end. The importance of having the best design and quality of work requires the official authority of the best available talent, *at least* as much as for other municipal work.

Water pipes are laid according to regulations. Gas pipes are carefully inspected as to their sizes, directions, bends, position, etc., in order to prevent accidents. But drain pipes, on the condition of which depends to so great an extent the health and lives of our families, receive no attention whatever in this city. The first requirement, therefore, is, that we should have municipal regulations in accordance with the latest information that the respective sciences furnishes us; and the second, that we should have an efficient system of carrying them out, by intelligent management, by licensed plumbers and by inspectors, placed under bond.

I hope to be able at some other time to lay before you some regulations of this character, compiled from the long and costly experience of the largest cities of the world.

Sewers.

The second branch of the whole subject is that of sewers, which are to collect the discharges from the houses and the washings from the streets, and to convey them to places where they can do no harm.

I will not enter into the question of the merits of having sewers at all in our streets. Much may be said against them. By our habits and all the costly present arrangements, we have, however, made them a necessity. But a sewer will never be anything but a powerful enemy in our midst, and if not under perpetual supervision will some day bring sorrow to our homes. To reduce the evil to a minimum, it is absolutely necessary that all the works should be designed, built and maintained according to the latest and most approved methods of the science of sanitary engineering, and should have far more care bestowed upon them than is generally done and believed to be necessary.

In our city the sewers are divided into branch and main sewers. The former collect the refuse directly from the houses and streets; the latter receive the discharges of the branch sewers and convey them directly to the rivers. I shall, as with the house drains, first give the requirements of a perfect system, as agreed upon by the best sanitary engineers, and then describe the principal features of our sewers, which have an aggregate length of nearly 200 miles, and state wherein they do not fulfill these requirements, and how the defects may be greatly improved.

A perfect system of sewerage demands the following conditions:

a. To allow no decomposition of organic matter to take place under conditions favorable to the propagation of unhealthful influences.

This can be accomplished by:

1. Water-tight sewers.
2. Rapid reception and conveyance, together with effectual discharge of all sewage and storm water.
3. Proper ventilation.

b. To be readily accessible in all its parts.

This is mainly accomplished by a sufficient number of man-holes and lamp-holes.

c. To be built with a uniformity of design, and in the best practical manner.

d. To be designed with reference to economy of first cost and maintenance.

BRANCH SEWERS.

Our branch sewers have a clear diameter of three feet, and are originally circular in form. They are built with a four-inch ring of brick, the invert being usually laid dry and the arch built with lime mortar. After several years they are found to be more or less elliptical, the long axis being horizontal, which, when well built, should not occur. If the ellipse is too flat, then the arch falls down. If it does not come to this, it has a form which gives for the usual flow, a large surface of friction for the amount of water, precisely the opposite of what is desirable for a perfect sewer, as the velocity is thereby diminished and a deposit gene-

rally caused. As the bricks in the sewer are not laid carefully, the sides are very rough, which impairs the velocity of the flow and allows solid particles to adhere and decompose; and, in some cases the sewer retains sufficient solid matter to fill up and require manual labor for cleaning it.

There has been no systematic provision for ventilation. Among all the devices for this purpose, none seems to answer better, provided the sewers are properly maintained and kept clean, than to have frequent openings into the streets, for the free entrance and exit of air. But our man-holes, built at intervals of from 200 to 400 feet, require tight-fitting cast-iron lids, because of the stench generated in the sewers on account of their imperfect condition.

The connections of the house drains with the sewer are made by the plumbers. The city reserves the right to inspect the connections; but, judging from the fact that by far the most breaks in our small sewers occur just where such connections have been put in, this also cannot have been done very perfectly.

We see that the most important of the above requirements have not been fulfilled. Our sewers are not water-tight, but allow sewage to soak into and penetrate the ground instead of taking it away. The flat bottom and the roughness of the sides reduce the velocity considerably, which either prevents the removal of the sewage before decomposition, or actually causes a deposit.

There is no ventilation, no ingress or egress of air, except by forcing the traps that lead into our dwellings. They are not built in the best practical manner, nor with reference to the cost of maintenance, which has been immense. About $100,000 are yearly expended to keep our sewers in repair.

I will now try to show that a system of pipe sewers, twelve and fifteen inches in diameter, would answer the above requirements in a far greater degree. Engineers have until recently preferred to build sewers very large, so that, as has often been said, there will be a chance for considerable deposit and still enough room for the water to flow. But this is in opposition to the first and principal requirement of a perfect sewer. It should not be a sewer of deposit, but should convey the sewage as rap-

idly as possible to the place of its final discharge. The fact now recognized is, that all increase of size above the required capacity, is an actual injury, because it diminishes the scouring power of the current and increases the amount of space to be ventilated. Twelve- and fifteen-inch pipes have more than enough capacity to take away the heaviest rainfall in our city for a length of several squares. The whole city of Saratoga, including the drainage area of a small run, has been effectually drained by a single three-feet sewer. As the requisites of quality and strength of vitrified pipes are now so well understood, failures occur very rarely, if ever, as long as proper skill and care are exercised in laying them. They are extensively used in the best drained cities of the world. As it is entirely practical and even economical to lay pipes in a perfect manner, it cannot be urged as an objection, that they have occasionally failed from improper construction.

The main advantages are as follows:

1. They are water tight when properly jointed and bedded.

2. Owing to their smoothness they will rapidly receive and convey all sewage, when they are carefully laid to the proper grades and curves. They will admit of a smooth and neat connection with the house drains, thereby, likewise, increasing the velocity.

3. They can be properly ventilated. At present, the prevailing opinion among sanitary engineers is, that all sewers should have free communication with the atmosphere as often as possible, through open man-holes. The oftener the air in the sewer can be replaced by a fresh supply the better. The man-holes being of the same size, a 12-inch pipe would stand a much better chance of having its air renewed, as it contains only one-ninth as much as a three-feet sewer. As the flow is more rapid, it would draw the air with it and help the exchange. As there is a quicker discharge and a smaller surface exposed, the sewage will be less liable to decompose and vitiate the air.

4. They can be readily accessible when properly built and provided with man-holes and lamp-holes.

5. There is no experience, so far as engineering is concerned, that prevents them from always being built in a perfect manner, that is, with regular grades and lines, with perfectly tight joints,

and with such foundations as will make an uneven settlement, breaking the pipes or joints, very rare, if not impossible.

6. They are at present cheaper than three-feet brick sewers. The cost of maintenance would be much less, and they could be thoroughly cleaned by a stream of water from a fire-plug.

MAIN SEWERS.

The last part of the subject is the consideration of the main sewers, which finally convey the sewage to the rivers. By regulation, the size of a main sewer must be sufficient to enable it to discharge an amount of storm water equal to a rain-fall of one inch per hour. The consequence is that our sewers are extremely large, and, as I believe, they can be shown to be entirely too large. The matter is a serious one, as it involves a great expenditure of money. If, for example, the provision for a half-inch rain-fall would be ample, the cost of the sewers of our city would be diminished several millions of dollars.

Mr. Chesbrough, of Chicago, says that in England it is the practice to allow for the discharge of half an inch of rain together with the greatest amount of sewage. He adds, however, that this rule, which is also extensively applied in the United States, must be modified in accordance with the local circumstances that bear upon the case, and if doubt should exist let the chances of error be in favor of liberal sizes, but avoiding extremes.

Boston, Providence, New York and Philadelphia have, according to the Smithsonian Contributions, about the same rain-fall at the time the heaviest showers occur, and would therefore seem to require nearly the same capacity for their sewers. In Boston the sewers that were calculated for one-half inch of rain-fall have been found satisfactory. In Providence, which has the best drainage system in the United States, they allow, after long and careful examination, for a little over one-half of an inch of rain-fall, and are perfectly well satisfied. In New York they calculate for one inch. But, were the city not so peculiarly situated, being a long narrow strip of ground between two rivers, which gives but small drainage areas, and consequently comparatively small and inexpensive sewers, their attention would likely have been drawn to the subject more closely on account of the

vast expense. Charles H. Haswell says of New York "that the entire sewerage of the city and the drainage of its suburbs is at variance with propriety, opposed to the advancement of the city and the interest of its inhabitants, at variance with the science of engineering, productive of disease, etc." It can therefore not be a model worthy of imitation.

In Philadelphia we also calculate for one inch of rainfall to reach our sewers. The drainage areas being very large, the sewers, therefore, become immense. Leaving out the basins of the Wissahickon, Pennypack and Tacony creeks, containing respectively about 43 000, 23 000 and 35 000 acres, which cannot be turned into sewers, we have the Mill creek, draining about 3 000 acres, requiring a sewer 20 feet in diameter for about two miles in length; the Hart creek sewer, which drains about 2 000 acres, is to be 13 to 16½ feet in diameter for about two miles; the Honey Run sewer will drain over 4 000 acres, and at six miles above its propable outlet has already a diameter of 14 feet, and so on. It can readily be seen what stupendous works we have in prospect. Roughly estimated we shall need, at least, three millions to provide for main sewers probably becoming necessary in the next twenty years. How important, therefore, is the question of size!

From personal observations, I believe that we have never had a shower sufficiently heavy to fill any of our largest sewers, provided they were not tide locked and otherwise improperly built, except, perhaps, at the entrances, where the water is naturally dammed up.

Experience tells us that only a portion of the rainwater finds its way into the sewers; the rest is either evaporated or absorbed, especially when we have the heaviest storms.

We also know that it takes considerable time for the rainwater to reach the sewer and to flow through it, the storms generally ceasing in the mean time. Mr. Roe, of London, found, when one-half inch of rain fell in three hours, the effect of the storm in the sewers had not ceased for 12 hours.

Recent investigations have shown that the capacity of small channels is greatly affected by the character of the wetted perimeter: that a very smooth channel may carry as much water as

a very rough one of nearly twice the size. By a better class of construction, therefore, a great saving could be obtained.

Finally, as main sewers are massive and strong, they could stand a considerable upward pressure, in case they *should* be completely filled by an extraordinary shower.

From all these facts, it is evident, I believe, that we could reduce the size of our main sewers nearly one-half, without running any risk. And if there should be some damage to pay occasionally for the flooding of a few cellars (which is not even probable if safeguards are provided), it would be an insignificant amount compared with the interest on the capital invested for an increased size. Here, also, it may be said: the smaller the sewers the easier it is to ventilate them, and the greater will be the velocity for the same amount of sewage, and the more effectual the discharge.

The *shape* of our main sewers is circular; occasionally they have a flat bottom. There should be a proper distinction made in the design between arch and invert. The *arch* must resist external pressure, and the science of statics gives readily the best form for any conditions. The earlier sewers have not been satisfactory in this respect. Only those built during the last two or three years have answered the requirements of stability and good workmanship.

In designing the shape of the *invert*, we should be governed by another element. A certain minimum velocity is required in all sewers that are to be self-cleansing, and when we decrease the wetted perimeter, in proportion to the sectional area, we increase the velocity. In the case of sewers, which, between the rain storms, have only a small stream flowing in them, we should insure to this mininum quantity the greatest velocity. This can be done best by the egg-shaped section, which is extensively used in the best drained cities, and answers admirably. In Philadelphia it has not been used. The bad results from this custom can be observed in many of our sewers.

Ventilation has not yet been introduced, and it is indeed a very difficult subject. Small pipes are easily ventilated, but large sewers seem to require some artificial assistance. The subject is as yet in its infancy, and the opinions and experiences differ so much that it seems impossible at present to form a satisfactory

judgment. I will only state that in London large ventilating shafts proved a failure, and in Frankfort, the best drained city in the world, they have been reported a success. A rigorous study of the details however, may lead to some satisfactory conclusion.

Having hastily reviewed the main points of a very extensive and for us very important subject, it will be seen that it needs sincere and early attention and study; but more than that, it needs *action*. Much has been said by physicians and engineers, but almost nothing has been done.

We hear continually something said about our bad drainage, but few seem to know just where the technical imperfections are. It appears, that the actual facts about our whole system, in its construction and in its workings, have not been rightly understood.

As I have given the matter some study, and as it seems to be justly of general interest to the community at present, I thought it a seasonable subject to present to you this evening.

III.

BEARING PILES.

The Principal Formulæ for their Sustaining Power.

By R. Hering, C. E., Member of the Club.

Read March 16, 1878.

Owing to the diversity of opinion among the authors of text and pocket books, about the most reliable of the various formulæ for the sustaining power of piles, the practical engineer often feels very uncertain which of them to use, and therefore adopts sometimes unreasonably high factors of safety, at the expense of economy, to guard against a possible deficiency, or, on the other hand, occasionally meets with failures.

In order to see more clearly into the relative merits of these

formulæ, I examined, as far as possible, the original works and papers in which they were presented, and found that by properly analyzing and comparing them many of the discrepancies disappeared, and a better judgment of their respective values could be obtained.

The following is a brief account of the results of my comparison. The *complete* tables with formulæ, numerical values, etc., are being published in pamphlet form by George H. Frost, Editor *Engineering News*, Chicago.

While collecting the formulæ I also extracted the opinions and experience of the authors, whenever given, on matters belonging more or less to the subject. These are summed up as follows:

"Nearly all authorities say that a *heavy ram* with a short fall is much to be preferred to a light one with a long fall. Any increase of fall beyond 40 feet, even in the best machines, gave no increase of penetration in the sandy soil at the Brooklyn Navy Yard. Some think the weight of the ram should be in proportion to the sectional area, others to the total weight of the pile. Becker concludes from a theoretical examination, that the most economical weight of a ram is equal to the weight of the pile. Ordinarily, piles from 10 to 14 inches in diameter are driven with rams weighing 1,200 to 2,000 lbs.

"It has been observed that *quick blows* with a heavy ram give a greater penetration at a less expenditure of power than slow blows with a light ram. In sand or silt, blows should follow rapidly in order to prevent the ground from settling around the pile before the next blow of the ram.

"On account of the many uncertainties in connection with piles, a *wide margin of safety* is recommended by all authorities, at least for important cases. It is sometimes impossible to tell how much of the sustaining is due to a 'solid bottom,' and how much to friction alone. There is often no guarantee that a pile will not steadily sink under a heavy quiescent pressure applied continuously and unremittingly, when it withstood perfectly a corresponding sudden blow of the ram. This may be feared especially in clays. The vibrations of the structure may in time produce unexpected settlements, or when certain clayey soils become very wet adjoining the piles, thereby lessening the friction. On the other hand, there are circumstances which tend to increase the strength after a lapse of time. The soil between the piles sometimes, especially if sandy, becomes more compact and increases

the friction, and often the soil itself will carry a considerable portion of the weight.

"It is the general opinion that piles should never be less than 6″ in diameter and rarely over 18″, and that the diameter should not be less than $\frac{1}{20}$th of the length, unless the soil is very stiff.

"Many writers give the nearest distance which piles should be apart, as $2\frac{1}{2}$ feet from center to center, because large piles, especially when driven closely, will force each other up. Should this ever be feared, then the piles ought to be driven with the butt end down, commencing at the center of the area and working toward the sides. The ordinary distance is 3 feet apart; for light work it is from 4 to 5 feet.

"Elm, spruce and oak are considered the best materials for piles.

"Becker gives the most economical weight of a '*punch*' or '*follower*' as $1\sqrt{w+p}$ lbs."

Most authors designate two distinct classes of bearing piles. The first consists of those which are driven to a perfectly solid foundation, and act as pillars or columns of support, and which are designated by the name *Columns*. The other class consists of such as derive their supporting power from the friction of the material through which they pass. These alone are properly called *Piles*. The formulæ are necessarily based on different principles and must be considered separately.

COLUMNS.

The values for the safe load, when the pile acts as a column, is given directly per square inch sectional area as follows:

Rankine & Mahan, 1000 lbs.

Perronnet, 786 to 990 lbs.

Stoney, $\frac{1}{10}$ of the crushing weight of the timber when dry.

As these values sometimes ascribe a much greater bearing capacity to the piles than when friction alone is the supporting power, great care must be taken in applying them, remembering that they are only reliable when resting on a firm foundation. Careful judgment must be exercised as to whether this is entirely or only partially true, in which latter case a proper allowance must be made.

It should also be remembered that the above values are safe

crushing resistances of wood without regard to length of columns. Therefore they can only be valid when the ground is sufficiently compact to prevent lateral flexure of the piles; otherwise the reductions necessary for 'long columns' must be made.

If the column has been driven to a perfectly solid foundation, the following formula may be useful in ascertaining what weight of ram will be necessary for a given fall, or what fall for a given weight, to compress the material of the pile to its limit of elasticity, beyond which it should never be strained by the blow of the ram:

$$\text{Height of fall} = \frac{\text{Sect. area} \times \text{length}}{2 \times \text{Weight of ram}} \times \frac{\text{Co-eff. of elasticity}^2}{\text{Modulus of elasticity}}$$

For most kinds of timber it will suffice, to say:

$$\text{Height of fall} = 405\,\frac{\text{Sect. area} \times \text{length}}{\text{Weight of ram.}}$$

Piles.

All formulæ developed from purely theoretical speculations regarding the resistance of the frictional surface of the pile in the ground, and containing certain co-efficients for different qualities of earth, have been omitted, as the only method which can be depended on in calculating the sustaining power of piles held by friction, is the experimental one, which introduces the actual distance which a pile sinks under the last blow. Only the formulæ based on this method have been collected and from authors well deserving our confidence. For the purpose of comparison they were arranged into two groups; the first containing those which are derived by theoretical reasoning, and subdivided into such that consider or neglect the compressibility of the pile, and the second containing those which are derived from or verified by experiments.

As the factor of safety in each formula indicates solely a personal judgment, and has nothing to do with the formula itself, but mainly as it causes large differences between some formulæ, it has here been taken out and given separately. They show a great variety of opinion.

Rankine gives $\frac{1}{2}$ to $\frac{1}{10}$, according to the character of the work.

Weisbach gives $\frac{1}{10}$ to $\frac{1}{100}$.

Trautwine gives $\frac{1}{2}$ to $\frac{1}{3}$.

Redtenbacher, Brix and Becker give $\frac{1}{4}$ to $\frac{1}{6}$.

Sanders gives $\frac{1}{3}$ to $\frac{1}{8}$, the latter for heavy structures.

Mason considers $\frac{1}{4}$ sufficiently safe for ordinary work.

Nystrom gives $\frac{1}{6}$.

McAlpine gives $\frac{1}{3}$ when there is no danger of vibrations of the structure being communicated to the piles, otherwise he recommends $\frac{1}{6}$.

A series of numerical values of extreme loads (not considering the factor of safety) were calculated with each formula for rams weighing 2,000, 1,000 and 500 lbs., each falling 30, 10 and 5 ft. A glance over the results as thus obtained will show the general tendencies of the formulæ to be as follows.

Considering the compressibility of the pile are formulæ of Rankine, Weisbach, Brix, Becker and Redtenbacher. For light rams they are all practically alike, except the one of Redtenbacher which is very much the safest. For heavy rams, Rankine gives the greatest sustaining power; then Weisbach and Redtenbacher; Brix and Becker giving the least.

Neglecting the compressibility of the pile are formulæ of Nystrom, Brix, Becker, and two of Weisbach, which are identical with those of Sanders and Mason. All except Brix and Becker's, which appears unreasonably safe when compared with the rest, run nearly parallel in their values, Nystrom's being the safest, then Weisbach—Mason's and finally Weisbach—Sanders'.

Derived from and verified by experiments are formulæ of Sanders, Mason, Trautwine and McAlpine. For a high fall, Trautwine's is the safest; next are those of McAlpine and Mason; Sanders' gives about three times the sustaining power of Trautwine's formula; by using their own factors of safety, however, the two run nearly alike. For low falls, we find Sanders' and Trautwine's formulæ giving nearly the same results, without their own factors of safety; Mason's is somewhat safer; but McAlpine's gives negative values, which is absurd, and shows that its application is limited to high falls.

By a close examination, it appears that the following formulæ

seem to deserve the preference for general application, as being safe and economical under all ordinary conditions.[1]

Considering compressibility of pile.

$$\text{Weisbach}: \ L = F \left\{ \frac{w\,h}{s + \dfrac{l\,w\,h}{2asE}} \right\}$$

Neglecting compressibility of pile.

$$\text{Weisbach — Mason}: \ L = F \frac{w^2 h}{s(w+p)}$$

Simpler, though not quite as safe, is

$$\text{Weisbach — Sanders}: \ L = F \frac{wh}{s}$$

All values of L should never exceed the safe crushing resistance of the pile.

Finally, the importance of the value of the factor of safety may be seen from the fact that all of the formulæ compared, except one, could be made to give the *same* result merely by selecting factors of safety between $\frac{1}{2}$ and $\frac{1}{10}$. It appears, by comparing the opinions, that $\frac{1}{3}$ to $\frac{1}{5}$ would be a proper value for temporary or light work, and $\frac{1}{6}$ to $\frac{1}{10}$ for heavy work, especially when piles are held by clay or subjected to vibrations. The exact values between these limits must be determined with reference to the circumstances of each case.

[1] L = safe load which a pile can bear.
F = factor of safety.
w = weight of ram.
p = weight of pile.
h = height of fall of ram.
l = length of pile.
s = distance which the pile sinks under the last blow.
a = sectional area of pile.
E = modulus of elasticity of the material of the pile.

IV.

ON THE PROPOSED REMOVAL OF SMITH'S ISLAND.

By Prof. LEWIS M. HAUPT, President.

Read April 20th, 1878.

The commercial interests of Philadelphia have developed to such an extent as to create a demand for greater wharfage facilities with deeper water; and that cereals and merchandise may be delivered without too many handlings, it is advisable that cars should be run immediately alongside the vessels to be laden. To accomplish this it is proposed to lay tracks on Delaware avenue, already too narrow, and to make provision for the space thus occupied by extending the Port Warden's line farther out and thus contract the river channel, now only about 800 feet wide at the narrowest part. Several of our largest shippers have requested permission to extend their wharves several hundred feet. Were this to be allowed in a few isolated cases it would introduce dangerous barriers to navigation, and if an advance be made all along the line it would seriously contract the channel, unless a portion of Smith's Island can be removed.

The project is by no means a physical impossibility, as much larger deposits have been successfully taken away. The work of improving the river Neva in Russia is one of far greater magnitude, as the following clipping from the *Ledger* witnesseth:

"Following the large order from Russia for Philadelphia locomotives comes the information that the Russian Government has just concluded, through Major W. R. Bergholz, a contract with the Morris & Cummings Dredging Company of New York, for deepening to a uniform depth of twenty feet the channel of the river Neva, between Cronstadt and St. Petersburg. Twenty-five thousand dollars were cabled to Russia last week as earnest money. The dredging 'plant' will cost $200,000. Most of it will be constructed in this country, and will be on hand ready for operation on 1st of May next. The quantity of mud, etc., to be excavated is estimated at 15,000,000 cubic yards, and the work must be completed in four years. (The contract was obtained after sharp competition with English operators.)"

To widen the Ship Channel of the Delaware River 1,000 feet along the Smith's Island front, and to a depth of 18 feet, would require the removal of only about 5,000,000 cubic yards of material, at a cost of about $1,000,000.

The same width and depth of channel may be obtained, if desired, for less than $\frac{1}{10}$ the cost of dredging, by a careful adjustment of the *regimen* of the river by auxiliary constructions such as jetties, rip-raps, sand fences or bottom-dams. Before these structures can be located precisely, it will be necessary to make a careful examination or survey of the river to determine its surface and mean velocity, the nature of its bed, its cross section, the directions of its banks and currents, whether straight or sinuous and its longitudinal slope. These quantities are evidently functions of each other, and together constitute what is known as the *regimen* of the river. So mutually dependent are they that a change in any one will affect them all.

The tendency of rivers is to maintain a constant *regimen*, and this fact is the key to the solution of many problems relating to river improvements.

All fresh water flowing through alluvial deposits carries with it in suspension more or less earthy matter. We find, therefore, a continual tendency to deposit where the velocity is least, and to scour where it is greatest, and this mechanical action of water is constantly pushing the river bed downwards to the sea. It is estimated that the "Mississippi annually transports to the Gulf a volume of alluvion one mile square and 241 feet high, weighing over 400,000,000 tons, and at the same time it pushes over the bar at its mouth an amount equal to $\frac{1}{10}$ of that sum," making altogether over 272,000,000 cubic yards. This is far beyond the limits of our present mechanical possibilities. Thus the river furnishes its own motive power, gathering up its load as it rolls along, and dumping it at the end of its course, not always, it is true, just where it is desired, unless the spot be indicated by depositing some obstruction, in which case it will not fail to notice the sign "dirt wanted here," and continue adding until its *regimen* is re-established, when it will move on as before.

Let us assume a straight length of river-bed of uniform cross section, a certain fixed stage of water and inclination, direction

and nature of bed, and we will find the discharge will be constant, or the water and its suspended earthy particles will move on with a uniform velocity, some being deposited, it is true, while others are pushed along or gathered up; but the mean velocity of the parabola representing the wave front will remain uniform. So soon, however, as the above relations are disturbed, the effect becomes at once manifest. Suppose, for example, the cross section be increased; the velocity would be reduced, and, consequently, the carrying and scouring capacity being limited, deposits would be formed; or if a bend be introduced, it would retard the threads of the current on its side of the stream, while those of the opposite side, flowing faster, must return to fill the vacuum which would otherwise be created, and thus be drawn over towards the bend to receive a new impulse from the inner threads, and by these constantly recurring differences of velocities cause the alluvium to be precipitated.

Again, should one stream intercept another of lesser volume, the mouth of the latter would become choked up with a bar, in consequence of the reduced velocity of its currents, which will then spread out laterally in the effort to maintain a constant discharge, and so form deltas. For this reason, I do not believe the improvement at the Southwest Pass to be a permanent one. The effect will ultimately be to elongate the bar into the deeper water of the Gulf, but the extension will be so gradual that the expense of maintaining an open channel will be very slight.

On the other hand, anything tending to reduce the cross section and so increase the velocity or discharge will produce a scour, and unless the bed be of rock or hardpan, will deepen or widen the channel. Such contraction may be accomplished in two ways, either laterally by drawing in one or both banks, or vertically by filling up the bottom to a limited height. As a consequence of the principles just enunciated we will find in an alluvial bed that where the distance between the banks is least the channel is deepest; where greatest it is shallowest, or bars are most numerous; where points jut out, forming elbows, there will invariably be a shoal on the lower convex shore, whilst on the opposite or concave side will be found the best channel; that at the efflux of a lake, or broad expanse of river, where the sev-

eral currents assemble before a final shoot through the contracted water-way, there will be deposits, and that at the mouths of rivers emptying into running water or beaches exposed to the winds and waves, bars will be formed, sometimes to such an extent as entirely to interrupt navigation.

Indeed, on the south shore of Lake Superior I have walked over the mouths of some small streams without suspecting their presence, and only discovered them by exploring inward.

With a knowledge of these principles it is possible to predict with almost absolute certainty just where shoals may be found by a mere inspection of the outlines of the stream.

The tendency of an elbow to cause deposits is one which constantly increases, so that the bar creeps up stream to meet the elbow and ultimately joins itself to it, forming a spit. This so greatly reduces the water-way as to cause erosions at other points, that the regimen may be preserved, and thus new channels are cut through. Hence the fickleness of rivers with low, earthy banks.

But to return to the application:

Smith's, or more properly, Windmill Island is represented, so far back as we have any authentic data, considerably farther down the river than at present, and it has been gradually creeping up stream, until now its upper end is about opposite Chestnut street. To corroborate the above theory I have examined the oldest obtainable maps in the Mercantile Library, Pennsylvania Historical Society, Philadelphia Library, City Engineer's Office, and Franklin Institute, with the following results:

The map of Thos. Holme, Surveyor General of the Province, 1681, shows a small island opposite Spruce street, and another much larger about opposite Kaighn's Point.

In 1762 Windmill Island extended from below Christian to below Spruce street, with bars all the way up to Cooper's Point. (No name to map.)

The map of Scull & Heap, 1777, gives about the same position for the island.

On the map of 1796 the island extended from below Shippen (now Bainbridge) street to below Chestnut, with a shallow channel across it opposite Spruce street; or, in other words, a

shoal showing above water between Spruce and Chestnut streets, but not yet joined to the body of the island.

Hill's map, 1808, represents six small islands or flats, dry at low water, extending from Christian to Vine.

In 1811 the island extended from between Shippen to between Market or High street, with bars at each end, the upper one being attached to the island, the lower reaching to Washington avenue.

The map of a survey by John A. Paxton, and drawn by Wm. Strickland, Engineer (1824), shows three islands extending from Catharine to Arch streets, with shoals at either end.

Port Warden's map (1836), having no date other than that of its presentation to the Franklin Institute, and no name, shows the upper end of island reaching above Chestnut street, with isolated upper bar extending to Arch street. The lower limit is not defined. (No canal shown.)

On the map of F. I. Roberts (1838) the island extends from Shippen to above Chestnut street, with a separate shoal reaching as far as Arch street, and a shoal below from Washington avenue to above Christian. (Canal shown as cut through.)

Map of Chas. Ellet, Jr. (1839); island from South to between Market street (with canal) and isolated bars above and below, the latter reaching from below Washington avenue to Fitzwater street, the former to Cherry street. Total length, with bars, 1⅜ miles.

The U. S. Coast Survey map (1843) shows the island as extending from Shippen to between Market, with ferry canal cut through, also a detached bar below, dry at low tide; one fathom depth just above Washington avenue, and an *attached* bar on the up-stream end extending to Cherry street, with one fathom of water below Callowhill street.

The surveys of Richard Hexamer (1868) limit the island by the prolongation of South and Chestnut streets; and Dyer's map of 1869 makes it reach from Shippen nearly to Arch street.

Of all these the only maps giving any information concerning the depths are those of the U. S. C. S., made in 1843, and the Port Warden's map having no date affixed; and, consequently,

the only one upon which any reliance can be placed is that of 1843. Still, a general comparison of all shows an average movement of the lower end of the island up stream from Christian to South street, a distance of 1900 feet in 106 years, or from 1762 to 1868.

From the comparative soundings of 1819 and 1836, as given on the Port Warden's map, and those of the Coast Survey of 1843, we are enabled to trace in *plan* the axes of the deepest water at those dates with the following notable results. In 1819 the axis was 250 to 300 feet from the Port Warden's line and very nearly parallel thereto. In 1836, after 17 years, it had evidently moved slightly towards the city shore, and in 1843 was still nearer from Race street to Chestnut street, approaching to within 90 feet of the pier heads at Market street. At Chestnut street it made a bend, convex towards Smith's Island, having its maximum ordinate opposite Walnut street, and remained outside the lines previously occupied to beyond the limits of the maps.

Theory would suggest that, as the approach to the island happened just opposite the canal cut for the Philadelphia and Camden Ferry Company, it must have resulted from the set of the current in that direction, and as there is a corresponding flexure of the deepest water line in the Jersey channel it corroborates the theory.

A search for the date of the opening of the canal resulted in a note from Mr. Thompson Wescott to the effect that "the work was authorized by Act of Council February 14, 1838, and damages assessed the same year at $2000. The canal, 150 feet wide, was cut soon afterwards"—he supposes in 1838–9. At first both sides of the canal were of the same length, in consequence of which it filled up rapidly; but by extending the upper side into the Jersey channel to intercept the flood-tide, and the lower side into the Pennsylvania channel to catch the ebb and cause a scour, it has since been kept open. The survey of 1843, four years after the opening of the canal, shows a very marked effect upon the axes of the currents. An examination of the *profile* shows 29 feet opposite the old Navy Yard, near the lower end of shoal, below the island. Thence the depth

increases with undulations to 58 feet at a point above Race street, at the upper end of the shoal above the island (distance 6800 feet), whence it suddenly shoals to 31½ feet opposite Cooper's Point (distance 3200 feet), at which place the river is widest.

It deepens again to 37 feet opposite the lower end of Petty's Island, and shoals gradually to a point above the Reading Company's wharves where there are but 19 feet of water; thence the depth increases to 26 feet at head of island, and, finally, runs up to only 13 feet, just below Fisher's point, where it pitches down suddenly to 38 feet.

Returning by the Jersey channel we find the distance somewhat greater, by the deep water line, because it is more sinuous in consequence of the greater width of channel and less depth of water. The same general observations obtain in this case as in the other, *i. e.*, where the river is broadest it is shallowest, and *vice versa*. Considering the profiles of the two channels together, we find, as a rule, the average depth greatest where the breadth is least, and the reverse, so that we may safely conclude from these (observations and deductions) that, if by any means the breadth or depth be reduced, the depth or breadth will be increased in consequence of the scour produced by the increased velocity given to the stream. This diminution of the sectional area may be produced either laterally by constructing jetties and levees, or vertically by forming sub-aqueous dykes or dams on the bed of the stream, and crossing the same either directly or obliquely. The latter being generally better, as it will change the direction of the resultant thread of the current so as to cause it to act more powerfully on the deposits to be removed. In applying these principles to the case in point, I should recommend the latter method of reducing the water-way by oblique dams (see map) constructed, first, of large stones thrown into the river on range lines established by signals erected on the island, and filling in on the up-stream side with rip-rap or ballast from vessels. The Pennsylvania end of the dam should be somewhat higher than that resting on the island, and no part of it should have less than thirty feet of water over it at mean low tide. As an auxiliary structure, I should extend the pier

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heads near Willow street (see map) down stream, at such an angle as to deflect the current towards the head of the island, and believe that, by thus expending a few thousand dollars, the present channel may be so deepened and widened as to avoid entirely the *removal* of the island. At present I do not think it advisable to remove any of the fast land which is now sufficiently protected by a casing of piles; but, on the contrary, I believe it would work serious injury to the harbor were any very considerable part of the island to be removed, as in that case the deep water channel would recede from the Pennsylvania shore, where bars would soon form and destroy the approach to the harbor. It is also serviceable as a breakwater, besides furnishing so much more room for stowage and wharfage, which are as essential to commercial interests as good water.

I do not believe the time has yet arrived when it will pay to pull up the piles now surrounding the island and set them further back, but I do think it would be expedient to deepen the channel close up to the present wharf lines on the island by the inexpensive method proposed.

The question will naturally arise as to the effect upon the lower reaches of the river from the alluvium thus disturbed. It is my opinion that it will not seriously affect the present navigable channel, but it will doubtless add to the magnitude of the bars already existing below Greenwich, Gloucester and Red Bank.

As to the time required to effect these changes it is impossible to make any predictions with certainty, for it will depend largely upon the stages of water, and be retarded to a considerable extent by the flood and stand of the tide, but it will doubtless improve the channel, at least as rapidly as the demand for greater shipping facilities increases.

A new survey of the river is now being made by the U. S. C. S., under the direction of Hon. C. P. Patterson, Sup'dt, the results of which will be looked for with great interest, as indicating more correctly than can be done by other means the exact location of any proposed improvement.

V.

WATER SUPPLY TO A STAMP MILL,

WITH NOTES ON KUTTER'S FORMULA.

By WM. F. BIDDLE.

Communicated by Chas. E. Billin, April 20th, 1878.

In making the necessary calculations for the location and construction of works to supply water to a quartz mill in the gold region of Venezuela, South America, the wide differences between the formulas given by well-known authorities for the flow of water in pipes and open channels became very apparent, particularly when applied to comparatively small dimensions. This mill of thirty stamps and the general plant of the company owning it, had previously been built close by the outcrop of the quartz vein and almost three miles from the nearest stream, in the disappointed expectation, on the part of the gentlemen then managing, of getting a supply of water by sinking to a moderate depth on the vein.

In order to show the conditions to which the formulas were applied, and also as illustrating some of the peculiarities met with in that country, a few descriptive notes are given of the works referred to.

These consisted (see profile) of a pumping station at the foot of a steep hill on the Yuruari River (an affluent of the Essequibo), delivering water 260 feet above the pump into a line of troughs (7 × 6 inches inside, made of inch boards) laid along the hill side on a descending grade of ·3 per 100 for a length of 4100 feet, the line crossing two deep ravines by inverted syphons (of boiler flues five inches diameter outside) 694 feet and 518 feet long, bringing the water to the second pumping station at the foot of a range of hills extending inland, whence the water was delivered 195 feet above the pump into a second line of troughs 10,450 feet in length—this line crossing another ravine by an inverted syphon 605 feet long—bringing the water into a ravine immediately below the stamp mill, whence a third pump

run from the mill boilers delivered it into the mill tank; the total surface length of the line, including the section and discharge pipes of the pumps, being 17,300 feet, and the total height gained from the river to the mill tank being 310 feet.

The pumps at the two stations were Worthington's Duplex, 16-inch steam cylinders, 8-inch plungers, and 10-inch stroke, with 6-inch suction and4-inch discharge pipes. The boilers were of locomotive pattern, having forty-five 3-inch flues eight feet long, and the exhaust of each pump was led into the smoke stack of its boiler. Check valves were placed in the discharge pipes close to the pumps, and inch pipes were tapped in just above the valves and leading to the boilers, which were thus fed by the pressure of the water column, though having injectors for use in case of necessity.

The boards for the troughs were sawed at the company's saw-mill, close by the stamp mill. The durable native woods, with one or two exceptions which are of very rare occurrence, are extremely hard and heavy. The boards come from the saw quite smooth, but it is almost impossible to drive a nail near the edge without splitting the wood, and, therefore, the side boards of the troughs were bored for the nails by a machine fitted up for the purpose in the saw mill. The troughs varied in length from twelve to sixteen feet, and were so stiff and strong that no supports were needed between the joints.

The pumps, boilers and fixtures, pipes, pipe fittings and tools, valves, bends, bolts and nuts, nails, indeed everything used in and on the work except the boards, had to be shipped by sailing vessels from New York up the Orinoco River some 300 miles, landed by lighters, loaded on ox-carts, and hauled 150 miles inland to the mines. Fortunately both pumping stations were close to the cart roads, but many of the syphon pipes had to reach their destination among the hills by being packed on donkeys.

The preliminary grade line for the troughs was run with a builder's level, or triangle, eight feet long and made of boards. This was really the quickest and handiest instrument that could be used, for almost every foot of the distance had to be cut through the dense tangle of vines, briers and lianas which form

the undergrowth of the tropical forests, and the amount of chopping was thus reduced to an opening just sufficient to drag the triangle along, while by driving pegs and keeping "tally" both the measurement and the grade line were obtained in the one operation with enough precision for preliminary work. The final leveling, after the line had been approximately located and cleared, was done with a "Heller & Brightly" small mining level, which proved a most satisfactory instrument.

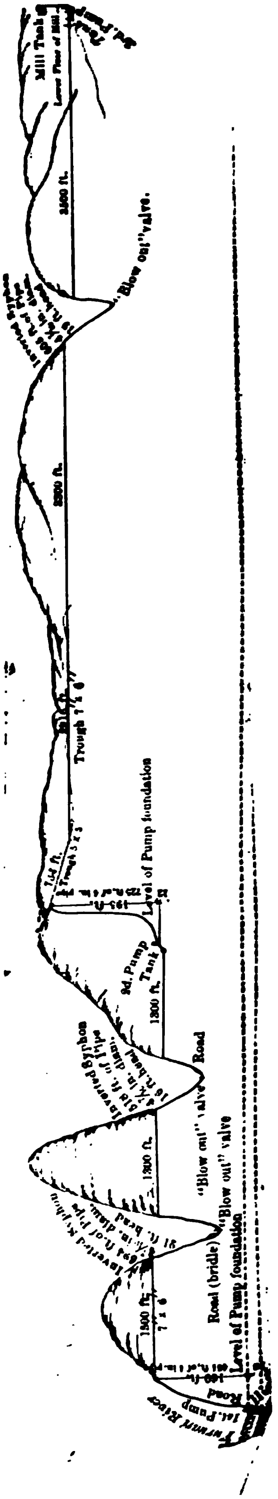
In calculating the heads to be given to the inverted syphons for a maximum discharge of thirty-five cubic feet per minute, two formulas were applied, Weisbach's for friction head (velocity head to be added), and Eytelwein's as given by Trautwine for total head, and also by Beardmore; with the following results:

	Feet long.	Eytelwein.	Weisbach.	Diff
1st. Syphon,	694	19·09	14·67	4·42
3d. "	605	16·71	12·83	3·88
2d. "	518	14·39	11·04	3·35
				11·65

Those by Eytelwein being thirty per cent. greater than those by Weisbach. In the absence of any record of the use of such small pipes (4·7 inches inside) as inverted syphons, it was thought wiser to take the larger results though involving a greater loss of elevation by almost twelve feet, and also to add two feet for bends and possible obstructions in the pipes, so that the heads actually given for the above lengths were twenty-one feet, nineteen feet, and sixteen and a half feet respectively. Trautwine remarks on this subject as follows:

"Recent experimenters state that the old formulæ in use, though generally sufficiently exact for ordinary practice, are to some extent defective. Weisbach asserts that for velocities less than 1½ feet per second (full one mile per hour) the heads given by the other formulæ are too small; and for higher velocities too great. On the other hand many measurements by competent engineers seem to show that the old formulæ give all the accuracy required in common practice."

The first trial of the works, and unfortunately the only one made before the engineer left the country, included only the first



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pumping station, 1500 feet of troughs and the first syphon, and was made under circumstances which rendered it impossible to test the performance of the syphon further than ascertaining that the 22 cubic feet per minute, then estimated to be flowing through the troughs, passed the syphon with no indication of filling the high side. The three syphons have now been in use nearly two years, but the only information yet received about them states, that when the works are furnishing more water than the mill needs the syphons show no sign of filling the high sides. This proves that the formula used was certainly *safe* in this case, but it is hoped that further details will soon be received by which to learn how much it is in *excess* of safety, and whether Weisbach's formula *might* have been safely used, since an unnecessary loss of twelve feet of elevation could hardly be considered by Mr. Trautwine as "sufficiently exact for common practice," and sometimes might be of very serious importance.

At the trial, during which the pump was run slowly, the water flowed in the troughs three inches deep, and a small piece of inch board floated through the 1500 feet in $9\frac{1}{4}$ minutes, or at the rate of 2·7 feet per second. If this was the true surface velocity, then taking the ratio between the surface and mean velocities at ·85, the mean velocity would have been 2·3 feet per second, giving a discharge of twenty cubic feet per minute. But the float was of such heavy wood that it was immersed its entire thickness, thus having its under side only two inches from the bottom of the trough, and there can be no doubt that if a strictly *surface float*, such as a thin disc of light wood, had been used, a considerably greater velocity would have been shown. Moreover the line of troughs in following the grade along the contour of the hillsides had almost constant changes of direction at the joints, while the formulas for discharge through open channels are given for *straight* channels, so that in order to compare them closely with the observed result in this case a correction should be applied to the result both for thickness of the float and for crookedness of the channel.

The differences between the formulas, both older and more recent, that were tried on this case, are in the values given to the co-efficient C in the formula for mean velocity, in feet per second,

$$V = C\sqrt{RS}$$

in which R is the hydraulic mean radius (area of water section divided by its wet perimeter), and S is the fall in one unit of length. Here the water section was 7 $\times$ 3 inches, or ·58 $\times$ ·25 feet $=$ ·145; and $R = \frac{\cdot 145}{\cdot 25 + \cdot 58 + \cdot 25} = \cdot 134$. The fall being ·3 per 100,

$$S = \cdot 003, \text{ and } \sqrt{RS} = \sqrt{\cdot 134 \times \cdot 003} = \cdot 02$$

Beardmore gives for ordinary use,

$$V = 94{\cdot}2\sqrt{RS}$$

And for "channels constructed with great care and straight in direction,"

$$V = 100\sqrt{RS}$$

The former gives in this case a mean velocity of 1·88 feet per second, and the latter two feet, corresponding at 85 per cent. to surface velocities of 2·2 and 2·35 feet per second respectively—both much below the observed result even without correction.

Weisbach gives 92·5 as the co-efficient of $\sqrt{RS}$, and other authorities vary from 68 to 100.

Bazin gives four different co-efficients for different degrees of smoothness in the material of the channel, all including the hydraulic mean radius as a factor, and the greatest being, for smooth plank (Higham's tables),

$$V = \frac{1}{\sqrt{\cdot 0000457\left(\frac{R + \cdot 098}{R}\right)}}\sqrt{RS}$$

This, applied to the case in question, gives a co-efficient of 112·36, and a mean velocity of 2·25 feet per second, corresponding at 85 per cent. to a surface velocity of 2·64 feet per second —still below the observed result even without correction.

Kutter's co-efficient includes as factors both the hydraulic mean radius and the inclination, and also a "natural constant" depending on the material, and for which a table of values is given, varying from ·009 for smooth plank to ·035 for rivers and canals full of weeds and stones. The formula is thus (Higham's tables)

$$V = \frac{\left(41\cdot6 + \dfrac{1\cdot811}{N} + \dfrac{\cdot00281}{S}\right)\sqrt{R}}{\sqrt{R} + N\left(41\cdot6 + \dfrac{\cdot00281}{S}\right)}\sqrt{RS}$$

Taking the value of N for smooth plank = ·009, this gives for the case in question a co-efficient of 119·145, and a mean velocity of 2·383 feet per second, corresponding at 85 per cent. to a surface velocity of 2·8 feet per second, which may be considered as agreeing closely with the observed result of 2·7 feet per second corrected for thickness of the float. But as this result was obtained in a channel very far from straight it would seem that even Kutter's co-efficient is slightly below the truth for this case. It is, however, very close, and much nearer than that of Bazin, which has been thought accurate when applied to small channels, though acknowledged to fail on large rivers.

According to Kutter's formula a depth of ·4 feet (say 4$\frac{3}{4}$ in.) of water in the troughs would have a mean velocity of 2·82 feet per second, which would give the maximum discharge of 35 cubic feet per minute, assumed in calculations for the line, with a surplus velocity of 3·32 feet per second.

The English translation of Kutter's work (by L. D. A. Jackson, A. I. C. E.) gives an interesting account of his investigations, in which a great number of recorded observations, as well as his own, were tabulated and compared in various ways and with most laborious research. Without going fully into the mathematical details, it describes the *method* of deriving the new co-efficient, which may be said to consist largely of a synthetic application of analytical geometry, by plotting the observed co-efficients as ordinates, to abscissas representing values of R, and to others representing values of S.

It is claimed that this new formula gives co-efficients of $\sqrt{RS}$ which will be found correct whether applied to a petty drain or an immense river. The formula of Humphreys and Abbot for *large* rivers had been accepted as the best yet proposed, but their modification of it for *small* streams, when applied to small channels with considerable inclinations, is said to fail as completely as that of Bazin on large rivers. But Kutter's formula is said to have been proved on the great depths and low inclinations of

the Mississippi, and to have given co-efficients equal to those found there by Humphreys and Abbot's observations, which have gone as high as 254·4. This and its close agreement with observed results in the case of the small trough which has been described, certainly seem to justify the claim made for it and entitle it to the confidence of engineers.

Kutter's investigations have demonstrated the following important and interesting facts: that for a constant value of N, when the hydraulic mean depth (R) is one metre, the co-efficient is practically the same at all inclinations; that with values of R *greater* than one metre, the *co-efficient increases* as the *inclination decreases*, an extreme case of this being the very high co-efficients for the Mississippi; while with R *less* than one metre, the co-efficient increases as the inclination increases up to $S = \cdot 001$, beyond which point any further increase of inclination has practically no effect on the co-efficient, which then varies only with R.

In the preface to the English edition of Kutter, the translator alludes to the anomalous fact that "the English-speaking races," while taking the lead in engineering progress in other directions, have been very far behind in hydraulics, one evidence and consequence being that this book which appeared in Austria, Germany and Switzerland in 1870, and was *immediately* translated into French, Dutch and Italian, was not published in England until *six years later*, and that too in spite of costly experience in the irrigation works in India of the necessity of more knowledge in this branch of science. An extract is also given from an article in *Engineering*, Dec. 31, 1875, which says that Neville's tables of velocity based upon Dubuat, "though expressed in hundredths of an inch, are in reality but the wildest guesses at the actual velocities in irrigation canals of ordinary dimensions. Col. Cautley relied upon Dubuat when he laid out the Ganges Canal, and found him but a rotten reed, for the water in every instance tore along at an unexpected velocity, and erosion of the bed and destruction of the works followed." The writer of this article then sets aside as unreliable for such work almost all the familiar text-books, both original and compiled, Continental and English, down to the time of D'Arcy and Bazin. If engineers

in England have been behind the age on this subject, it is to be feared that we in America have been more so, for the Continental scientific journals of Europe (in which Kutter's work was first published) are less known and read here than in England, and are hardly enough "quoted" in our own periodicals to keep the profession at large well posted on the progress in these countries—else some of our lately issued "Hand Books" would have contained Kutter's very important results.

Kutter's *Tables* are in metrical measures, and are therefore not so convenient for use here at present, as it is to be hoped they may be some years hence. A smaller but more comprehensive set of tables for open channels has been calculated in English feet from both Bazin's and Kutter's formulas, by Thomas Higham, Engineer of Irrigation Works in the Punjab, India, which can be recommended as convenient for use and reliable.

VI.

EMPIRICAL FORMULA

For Strength of WROUGHT IRON BEAMS, etc.

By Percival Roberts, Jr., Member of the Club.

Read April 20th, 1878.

The following formula is entirely empirical, and it is only because it has been found to give very good results in practice and to be very convenient for rough calculations that I venture to bring it to the attention of the club:

$$\tfrac{1}{2}\left(\frac{\text{area in sq. in.} \times \text{depth of bar in inches} \times 4}{\text{length of span in feet.}}\right)=L$$

L is the safe load in net tons uniformly distributed upon a laterally supported beam. If the load be upon the middle of the beam this result must be divided by 2; if it is upon any other point, the safe load at the center is to that at any other point as the rectangle of the segments at the point is to the square of

half the span. In the calculated tables for I beams published by the Trenton and Phœnix Iron Companies, different results are arrived at, although both take 12,000 lbs. per square inch of section, the reason being that there are some slight differences in the formula employed in the calculations. It is proper to remark that the weight of the beam must be deducted from the results obtained by all the formulæ used. The area of the bar is found by dividing the weight per yard by 10.

Below are given the calculated safe loads for Trenton and Phœnix beams by both their own formulæ and the above empirical formula.

The figures show that the Phœnix Company give from ·3 of a ton to more than 2 tons more weight for a load upon the same section of beam than is obtained by using the empirical formula, and that the Trenton Company give about as much less. The empirical formula holds a very fair mean between the two throughout, and would seem to be quite reliable.

PHŒNIX BEAMS, FOR TEN FEET SPAN.

Depth. Inches.	Weight per yard. Pounds.	Phœnix safe load. Net tons.	Empirical safe load. Net tons.
15	200	41·00	40.00
15	150	30·20	30·00
12	170	29·20	27·20
12	125	20·80	20·00
10½	105	15·50	14·70
9	150	19·70	18·00
9	84	10·80	10·08
9	70	9·20	8·40
8	65	7·40	6·93
7	55	5·40	5·13
6	40	3·50	3·20
5	36	2·50	2·40
5	30	2·10	2·00
4	30	1·80	1·60

TRENTON BEAMS. FOR TEN FEET SPAN.

Depth. Inches.	Weight per yard. Pounds.	Trenton safe load. Net tons.	Empirical safe load. Net tons.
$15\frac{1}{8}$	200	37·40	40·30
$15\frac{3}{16}$	150	27·55	30·37
$12\frac{5}{16}$	170	25·55	27·90
$12\frac{1}{4}$	125	18·85	20.41
$10\frac{1}{2}$	135	18·00	18·90
$10\frac{1}{2}$	105	14·30	14·70
9	125	13·40	15·00
9	85	9·45	10.20
9	70	7·60	8·40
8	80	8·40	8·50
8	65	6·75	6·90
7	60	5·05	5·60
6	50	3·80	4·00
6	40	3·13	3·26
5	40	2·45	2.66
5	30	1·90	2·00
4	30	1·50	1·60

DISCUSSION: By JAMES CHRISTIE, Corresponding Member.

Assuming that a bar of rolled iron, one inch square and one foot long, will utterly yield, under a load of 2400 lbs. or 1·2 tons suspended in the middle of its length, or that a flanged beam will yield, when its flanges are subject to a longitudinal stress of 40,000 lbs. or 20 tons per square inch,—and expressing the total area of cross section in inches by A, depth in inches by D and length in feet by L,—we will have for any solid rectangular section, the breaking load in the center in net tons:

$$W=\frac{1\cdot 2AD}{L}$$

In the case of a flanged beam having equal top and bottom flanges and the web merely sufficient to transmit the shearing strains the moment of resistance would be the longitudinal resistance of one flange, multiplied by the distance between centres of flanges, or 20 A' D'; equating this with the reaction of either support will

give $20\,A'\,D' = \frac{W}{2} \times \frac{L}{2} = \frac{WL}{4}$ = the moment of rupture for a load concentrated in the center of beam; reducing this equation so as to express A' and D' in inches and L in feet, gives $\frac{6\frac{2}{3}A'D'}{L} = W$. If the beam is reinforced by material in the web, the equation would become $W = \frac{6\frac{2}{3}A'D' + 1{\cdot}2ad}{L}$ where a is the area and d is the depth of the web in inches. It has been demonstrated that, in a beam of the latter form, $\frac{1}{6}$th of the area of the web may be added to the area of either flange, and the whole treated as a simple flanged beam.

This will give $W = \frac{6\frac{2}{3}\left(A' + \frac{a}{6}\right) D'}{L}$ with similar results to the previous equation.

By comparing this formula with the ordinary formulæ for rolled, double-flanged beams, it will be found that the rule given to the club by Mr. Percival Roberts, Jr., viz.: $W = \frac{2\,A\,D}{3\,L}$ will give a nearly correct result for the average resistances of the various sections, being too low for the thin-webbed and too high for the thick-webbed beams, but exact enough for practical purposes where strict accuracy is not required, and it has the merit of exceeding simplicity. T and L sections are frequently used as beams for roof purlins and similar purposes, where the local loads are light, and the material is more readily obtained in light sections than the double-flanged beam. These shapes used with table down and stem up, offer a very imperfect resistance to a transverse strain, the top of the stem under compression buckling readily in a lateral direction, unless rigidly supported. The following formula gives the average of several experiments with stem up:

$$W = \frac{0{\cdot}8\ A\ D}{L}$$

When applied with the table on top and stem downwards, the rule would become $W = \frac{2\ A\ D}{L}$ or the value of the

beam would be 2½ times greater than in the former position. This formula is derived from experiments on T sections in lengths varying from 6 to 10 feet, without any lateral support. It is certain that no such great disparity would exist if the beams were rigidly supported to prevent lateral flexure, as can frequently be done in their applications. Nor is it probable that L sections would yield as good results as the T sections. Of course, in all beams of ordinary construction the limit of length without lateral support must be borne in mind, as then the resistance to lateral flexure, and not the resistance to absolute compression, is the measure of stability.

For the deflection of beams having equal flanges, and proportions similar to the ordinary rolled beams, the following rule is a modification of one given by a prominent manufacturer:

$$\left.\frac{\text{Square of span in feet}}{\text{Depth in inches} \times 40}\right\} = \begin{array}{l}\text{the deflection in inches under half the}\\ \text{breaking load, evenly distributed.}\end{array}$$

With one-half the breaking load in the center of the beam, substitute 50 for 40 in the above. This will be a close approximation for the deflection at the elastic limit of the beam; for smaller loads the deflection will be proportionately less.

VII.

THE SCALES OF MAPS.

By Lewis M. Haupt, President.

Read Oct. 19th, 1878.

The object of this paper is to attempt if possible the removal of the ambiguities existing in regard to the use of ratios, as expressing the scales of maps and degrees of slopes.

Mathematical authorities are by no means agreed concerning the definition of the term ratio. They all maintain that it is an expression for the relation existing between two quantities, but differ in the manner of determining the value of this relation;

some, as Peck, Davies, Robinson and others, divide the second quantity or consequent by the first or antecedent; some, as Hutton, Alsop, Ray and others, divide the first by the second quantity, and still a third class, as Chauvenet and others, define it as being the quotient obtained by dividing one quantity by another. It may therefore be either $\frac{a}{b}$ or $\frac{b}{a}$, 2,000,000, or $\frac{1}{2000000}$.

The same confusion is found to exist in designating the scales of maps and drawings. Some publishers and engineers giving it as so many miles, or other denomination, to the inch; others, as so many inches to the mile. Again in expressing slopes many authorities use the tang. of the angle made with the horizon, that is, the height divided by the base or $\frac{a}{b}$, while others use the co-tang. or $\frac{b}{a}$.

Now if we consider the manner of obtaining the value of the ratio in a Geometrical Series or progression where *no* ambiguity exists, we find that as each subsequent term is obtained from its predecessor by multiplying by a constant factor called the ratio, so to obtain this factor or ratio we must necessarily divide any term by the *preceding* one, and as this is the only way in which its value can be determined, it establishes a rule which should be made to apply to all other cases.

We should then define a *ratio as being the expression for the value of the relation existing between two quantities*, and as *obtained by dividing the* SECOND *by the* FIRST.

The query then arises as to which quantity should be considered the first and which the second, and we answer that the *given material object* to be represented by the map or drawing is the *unit or measure* with which the other is to be compared. The map or drawing may be made of any convenient size, but the object to be represented is already fixed or constant in its dimensions, and hence, as the unit or standard of comparison, should be made the *divisor*, or denominator of the quantity expressing the ratio, it is consequently the antecedent or first quantity. To illustrate, let it be required to determine the ratio between a map and its original in nature.

The tract to be delineated in miniature is the fixed object, invariable in size, which is to be compared with the plot representing it, and which may be made larger or smaller according to circumstances, hence it becomes the unit of comparison, and is the antecedent or first quantity, and as such the denominator of the fraction expressing the ratio. The formula will then be:

Field : Plot $= \frac{P}{F}$. P and F being always reduced to the same denomination.

Thus a scale of $\frac{1}{5280}$ is 5280 ft. of field to 1 ft. of map or one mile to 1 ft. $= \frac{1}{12}$ of a mile to 1″, and not 12″ to 1 mile.

It is evidently *incorrect* therefore to indicate the scales of maps as so many inches to a mile as is frequently done. Take the case of the recent Geological maps of one of our sister States said to be plotted on a scale of 3″ to 1 ^{m} or 3″ to 63,360″$=\frac{63360}{3}$=21,120, that is to say, the map is 21,120 times larger than the State itself, a manifest absurdity resulting from considering the *map* as the first quantity or standard rather than the field itself

In such cases errors of interpretation can scarcely arise, as the intention is so evident, but there are numerous others that may lead to misconstruction, as where the drawings of small objects are nearly of the same size as the things represented—thus a scale of ½″ to 1″ would confuse a mechanic unless he happened to know which was the larger, the object or the drawing.

So the expression ¼″ to 1′ is likewise incorrect as it is the reciprocal of the ratio intended—the inches evidently referring to the drawing and the foot to the object. As it stands, applying the definition of ratio as deduced, it will be equal to $12 \div \frac{1}{4} =$ 48, making the drawing 48 times the size of the model—it should be 1′ to ¼″.

If it be remembered that *the antecedent always refers to the given object* and *the consequent to the drawing*, no difficulty can arise. It will always happen then that if the drawing is on a smaller scale than the thing delineated, the ratio will be a *proper* fraction; if larger, an improper fraction, and if equal the value will be unity, or $\frac{1}{1}$.

It is hardly necessary to call attention to the fact that the

number of scales in use is practically infinite, and that serious inconvenience results therefrom to Engineers and Surveyors whose work extends over several counties or States, making it frequently necessary to re-draw large sections of country. In compiling atlases it is the practice of publishers to vary the scales according to the amount of territory to be represented, that the sheet may be filled up, but nothing is gained thereby since the scale used for the greatest area to be represented will show with equal clearness all the features of any other area. Moreover the eye becomes accustomed to estimating distances on the maps, with sufficient accuracy for a reconnaissance, when the scale is uniform, but when variable it leads to great confusion, and especially when the publisher has neglected to indicate the scale, as sometimes happens.

It is very desirable to establish, if possible, either by recommendations of scientific societies or by general laws, some conventional scales for maps of various sizes. Taking a state of medium area as N. Y. or Penna. for the unit, and reducing it to a convenient size sheet of paper, say 4×3 ft., would require a scale of $\frac{1}{400000}$, the same as is used by the U. S. Coast Survey for general charts and reconnaisance, but too small for most other purposes. Larger States could be plotted on the same scale by dissecting them. Foreign countries couducting Geodetic Surveys have adopted such a system. In Prussia, Austria and Switzerland the plane-table sheets are plotted on a scale of $\frac{1}{25000}$. In Italy the field work is plotted on a scale of $\frac{1}{50000}$, and in Sweden $\frac{1}{100000}$. The older British charts and maps were made on a scale of 1 ^{m} to 1″ or $\frac{1}{63360}$, and the later maps of 1 ^{m} to 6″ or $\frac{1}{10560}$, but these latter, while not being large enough to show parish boundaries with sufficient accuracy, require about six times the amount of labor in their preparation and are inconvenient. The scale used by Prussia and Switzerland for general maps is $\frac{1}{100000}$, or one-fourth that of the detail sheets obtained from the plane-table surveys.

Populous, cultivated and mineral districts in Great Britain are plotted on a scale of $\frac{1}{2500} = 1$ ^{m} to 25·344″, partially cultivated and thinly settled districts, on a scale of 1 ^{m} to 6″$= \frac{1}{10560}$. For the plans of cities of over 4000 inhabitants a scale of $\frac{1}{500}$

or 1″ to 10·56 feet is used, and for towns and villages $\frac{1}{1056}$ or 1″ to 5 ft. is general.

Numerous other instances might be cited showing the great variety of scales in use, but these will suffice. It is evident that in Government or State Surveys some systematic connection may readily be established between the several scales used, and it is very desirable that this uniformity of scale be made more general. The scale adopted should be just large enough to show clearly all necessary detail. Anything more than this is a wasteful expenditure of time and money.

For general maps of States showing intercommunications, a scale of $\frac{1}{100000}$ will be found sufficiently large.

For maps of counties, *in toto*, a scale of $\frac{1}{50000}$ will enable all necessary features to be clearly represented: this scale applied to Lycoming Co., the largest in Penna., would require a map $6\frac{1}{2} \times 4\frac{1}{6}$ ft. For townships the scale of $\frac{1}{25000}$ is large enough, and furnishes an admirable size for the projection of Geological data.

For cities, towns and villages some decimal, sub-multiples of the above scales should be used. Cadastral maps of farms, parks or estates may be plotted on scales of $\frac{1}{250}$, $\frac{1}{500}$, $\frac{1}{1000}$, etc.

In indicating the degrees of slopes or the batir of retaining walls, the natural tangent of the angle which the slope makes with the horizon should invariably be used.

To save time in determining the relative values of some of the most important scales in use, and to aid in introducing the metric system of lengths, I have with the assistance of Messrs. Wm. M. Potts and J. W. Van Osten, Jr., prepared the accompanying tables of equivalents. The first, gives the number of Miles, Kilometers, Chains, Poles, Meters, Yards and Feet of territory which are equivalent to one inch of map for any given scale. The second, is the reciprocal of the first, and states the amount of map surface which would be covered by any one or more of the above units, for any scale.

Table of Map Equivalents giving for each

No.	Scale.	Miles.	Kilometers.	Chains.	Poles.
1	$\frac{1}{7349760}$	116·	186·6821	9280·0000	37120·0000
2	$\frac{1}{2090880}$	33·	53·1078	2640·000	10560·00
3	$\frac{1}{1267200}$	20·	32·18663	1600·000	6400·00
4	$\frac{1}{1200000}$	18·9393	30·4791	1515·15	6060·00
5	$\frac{1}{1013760}$	16·	25·7492	1280·00	5120·00
6	$\frac{1}{1000000}$	15·7828	25·3892	1261·62	5046·50
7	$\frac{1}{811000}$	12·8000	20·5994	1024·00	4096·00
8	$\frac{1}{760320}$	12·	19·3129	960·00	3840·00
9	$\frac{1}{635000}$	10·0221	16·1286	801·768	3207·07
10	$\frac{1}{633600}$	10·	16·09329	800·00	3200·00
11	$\frac{1}{600000}$	9·4696	15·2398	757·575	3030·30
12	$\frac{1}{506880}$	8·	12·87456	640·00	2560·00
13	$\frac{1}{500000}$	7·8914	12·6996	631·318	2525·25
14	$\frac{1}{400000}$	6·3131	10·1597	505·050	2020·20
15	$\frac{1}{380160}$	6·	9·65587	480·00	1920·00
16	$\frac{1}{375000}$	5·9185	9·5239	473·48	1893·92
17	$\frac{1}{316800}$	5·	8·04664	400·00	1600·00
18	$\frac{1}{300000}$	4·7348	7·61992	378·78	1515·15
19	$\frac{1}{240000}$	3·7878	6·09570	303·03	1212·12
20	$\frac{1}{200000}$	3·15656	5·07985	252·525	1010·10
21	$\frac{1}{190080}$	3·	4·827935	240·00	960·00
22	$\frac{1}{160000}$	2·5252	4·0638	202·02	808·08
23	$\frac{1}{150000}$	2·36742	3·80496	189·39	757·57
24	$\frac{1}{126720}$	2·	3·21866	160·00	640·0
25	$\frac{1}{120000}$	1·89393	3·05784	151·515	606·06
26	$\frac{1}{100000}$	1·57828	2·53995	126·26	505·05
27	$\frac{1}{80000}$	1·2626	2·0319	101·01	404·04
28	$\frac{1}{79200}$	1·2500	2·01166	100·00	400·00
29	$\frac{1}{76800}$	1·21212	1·9604	96·967	387·87
30	$\frac{1}{63360}$	1·	1·6093	80·00	320·00
31	$\frac{1}{60000}$	0·94696	1·52392	75·75	303·03
32	$\frac{1}{59400}$	0·9375	1·508737	75·00	300·0
33	$\frac{1}{50000}$	0·78914	1·26996	63·131	252·52
34	$\frac{1}{40000}$	0·63131	1·0159	50·50	202·02
35	$\frac{1}{39600}$	0·6250	1·0058	50·0	200·0
36	$\frac{1}{39370}$	0·62138	1·	49·7104	198·88
37	$\frac{1}{38400}$	0·6060	0·9752	48·484	193·93
38	$\frac{1}{38016}$	0·6000	0·9656	47·925	191·70
39	$\frac{1}{33792}$	0·5353	0·86146	42·666	170·66
40	$\frac{1}{30000}$	0·47348	0·7619	37·8787	151·48
41	$\frac{1}{25344}$	0·4000	0·64373	32·000	128·000
42	$\frac{1}{25000}$	0·39457	0·63967	31·5656	126·262
43	$\frac{1}{23760}$	0·37500	0·60349	30·	120·000
44	$\frac{1}{21120}$	0·33333	0·53589	26·666	106·666
45	$\frac{1}{20000}$	0·31565	0·50798	25·2525	101·0101
46	$\frac{1}{19800}$	0·31250	0·50290	25·	100·
47	$\frac{1}{19200}$	0·30303	0·48762	24·242	96·969

ineal inch of Map the following number of

No.	Metres.	Yds. and Ft.	of Actual Distance.	Where Used.
1	186682·18	204160·00	612480·00	Map of U. S. in atlas.
2	53107·86	58080·00	174240·00	Map af Pa.
3	32186·635	35200·00	105600·00	U. S. C. S.
4	30479·7	33333·33	100000·0	U. S. C. S.
5	25749·27	28160·0	84480·0	△ India.
6	25399·2	27755·77	83333·3	U. S. C. S.
7	20599·416	22528·00	67584·00	
8	19312·95	21120·00	63360·00	R. R. Va.
9	16128·6	17638·89	52916·66	U. S. C. S.
10	16093·29	17600·00	52800·00	U. S. Eng's.
11	15239·8	16666·6	50000·0	U. S. C. S.
12	12874·65	14080·0	42240·0	Eng. Ord. Sur.
13	12699·6	13888·8	41666·6	U. S. C. S.
14	10159·7	11111·1	33333·3	U. S. C. S.
15	9655·87	10560·0	31680·0	Ludlow's Rep.
16	9523·9	10416·5	31250·0	U. S. C. S.
17	8046·64	8800·0	26400·0	Barnes' Pa. Maps, 1851.
18	7619·9	8344·3	25000·0	U. S. C. S.
19	6095·7	6666·6	20000·0	U. S. C. S.
20	5079·8	5555·5	16666·6	U. S. C. S.
21	4827·935	5280·0	15840·0	Ludlow's Rep.
22	4063·8	4444·4	13333·3	U. S. C. S.
23	3804·9	4166·6	12500·0	U. S. C. S,
24	3218·66	3520·0	10560,0	Sherman's March.
25	3057·8	3333·3	10000·0	U. S. C. S.
26	2539·9	2777·7	8333·3	U. S. C. S.
27	2031·9	2222·2	6666·6	U. S. C. S.
28	2011·7	2200·0	6600·0	
29	1950·5	2133·33	6400·0	Geol. Sur.
30	1609·3	1760·0	5280·0	Fremont.
31	1523·9	1666·6	5000·0	U. S. C. S.
32	1508·73	1650·0	4950·0	
33	1269·9	1388·8	4166·6	U. S. C. S.
34	1015·9	1111·1	3333·3	U. S. C. S.
35	1005·88	1100·0	3300·0	U. S. C. S.
36	1000·0	1093·6	3280·8	
37	975·24	1066·66	3200;0	Geol. Sur.
38	965·59	1054·33	3163·0	
39	861·458	938·66	2816·0	
40	761·9	833·3	2500·0	U. S. C. S.
41	643·728	704·000	2112·000	
42	639·673	694·44	2083·333	
43	603·487	660·00	1980·000	
44	535·8969	586·66	1760·000	
45	507·98	555·5	1666·66	
46	502·906	550·00	1650·00	U. S. C. S.
47	487·617	533·333	1600·00	

Table of Map Equivalents giving for each

No.	Scale.	Miles.	Kilometers.	Chains.	Poles.
48	$\frac{1}{18818}$	0·29700	0·47796	23·760	95·04
49	$\frac{1}{15840}$	0·25000	0·40232	20·	80·
50	$\frac{1}{15000}$	0·23674	0·38099	18·9393	75·75
51	$\frac{1}{11880}$	0·18750	0·30174	15·	60·
52	$\frac{1}{10000}$	0·1578	0·25417	12·626	50·505
53	$\frac{1}{9900}$	0·15625	0·25100	12·500	50·000
54	$\frac{1}{9600}$	0·15151	0·24376	12·121	48·484
55	$\frac{1}{7920}$	0·12500	0·20112	10·	40·000
56	$\frac{1}{7200}$	0·1136	0·18378	9·0909	36·363
57	$\frac{1}{6000}$	0·09471	0·15285	7·5757	30·304
58	$\frac{1}{5940}$	0·09375	0·15092	7·5000	30·000
59	$\frac{1}{5000}$	0·078913	0·12695	6·31313	25·252
60	$\frac{1}{4950}$	0·078123	0·12582	6·250	25·000
61	$\frac{1}{4800}$	0·07575	0·121881	6·0606	24·242
62	$\frac{1}{3960}$	0·06250	0·100561	5·	20·000
63	$\frac{1}{3600}$	0·05681	0·091391	4·5303	18·1212
64	$\frac{1}{3333}$	0·05261	0·08463	4·2060	16·8242
65	$\frac{1}{3168}$	0·05	0·080466	4·	16·000
66	$\frac{1}{3000}$	0·04734	0·07610	3·7787	15·151
67	$\frac{1}{2970}$	0·04687	0·07541	3·75	15·000
68	$\frac{1}{2500}$	0·03945	0·06396	3·1565	12·626
69	$\frac{1}{2400}$	0·03787	0·06098	3·0379	12·1515
70	$\frac{1}{1980}$	0·03125	0·05029	2·5	10·000
71	$\frac{1}{1280}$	0·02020	0·032507	1·6016	6·406
72	$\frac{1}{1250}$	0·019728	0·031697	1·5767	6·307
73	$\frac{1}{1200}$	0·018939	0·030578	1·5151	6·060
74	$\frac{1}{1080}$	0·017046	0·027520	1·3636	5·454
75	$\frac{1}{960}$	0·01515	0·024376	1·2121	4·848
76	$\frac{1}{840}$	0·013258	0·021399	1·06057	4·2420
77	$\frac{1}{792}$	0·0125	0·02011	1·	4·
78	$\frac{1}{720}$	0·01136	0·018378	0·9091	3·6363
79	$\frac{1}{600}$	0·009471	0·015285	0·75757	3·0303
80	$\frac{1}{500}$	0·0078913	0·012695	0·63131	2·5252
81	$\frac{1}{480}$	0·007575	0·012188	0·60606	2·4242
82	$\frac{1}{360}$	0·00568	0·009139	0·45303	1·81212
83	$\frac{1}{300}$	0·004734	0·007610	0·37787	1·51515
84	$\frac{1}{240}$	0·003787	0·006098	0·30379	1·21515
85	$\frac{1}{198}$	0·003125	0·005029	0·25	1·
86	$\frac{1}{120}$	0·001894	0·003057	0·15151	0·6060
87	$\frac{1}{60}$	0·000947	0·001528	0·07575	0·3030
88	$\frac{1}{39.37079}$	0·0006213	0·001	0·0497101	0·1988405
89	$\frac{1}{36}$	0·000568	0·0009139	0·045303	0·181212
90	$\frac{1}{12}$	0·0001894	0·0003057	0·015151	0·0606
91	$\frac{1}{1}$	0·00001578	0·00002536	0·0012595	0·00505
92	$\frac{4}{3}$	0·000011835	0·0000190	0·0009467	0·003787
93	$\frac{2}{1}$	0·00000789	0·00001268	0·0006297	0·002525

lineal inch of Map the following number of

No.	Metres.	Yds. and Ft.	{ of Actual Distance.	Where Used.
48	477·96	522·72	1568·1	U. S. C. S.
49	402·325	440·00	1320·00	
50	380·99	416·66	1250·00	U. S. C. S.
51	301·744	330·00	990·00	
52	254·177	277·77	833·33	U. S. C. S.
53	251·004	275·000	825·00	
54	243·763	266·66	800·	
55	201·125	220·00	660·	
56	183·782	200·	600·	
57	152·854	166·66	500·	
58	150·924	165·00	495·	
59	126·950	138·888	416·66	U. S. C. S.
60	125·8238	134·166	412·50	
61	121·88175	133·333	400·	
62	100·5625	110·0	330·	
63	91·391	100·	300·00	
64	84·6334	92·592	277·777	U. S. C. S.
65	80·0466	88·	264·	
66	76·1057	83·333	250·00	
67	75·4138	82·5	247·5	
68	63·9673	69·444	208·33	U. S. C. S.
69	60·9811	66·666	200·	U. S. C. S.
70	50·2906	55·55	166·66	
71	32·5079	35·555	106·66	U. S. C. S.
72	31·6973	34·7222	104·166	U. S. C. S.
73	30·578	33·3333	100·	U. S. C. S.
74	27·520	30·	90·	
75	24·3763	26·666	80·	
76	21·4046	23·3333	70·	
77	20·1125	22·	66·	
78	18·3782	20·	60·	
79	15·2854	16·666	50·	
80	12·695	13·8888	41·666	U. S. C. S.
81	12·18817	13·3333	40·	
82	9·1391	10·	30·	
83	7·61057	8·3333	25·	
84	6·09811	6·6666	20·	
85	5·02906	5·555	16·666	
86	3·0578	3·3333	10·	U. S. C. S.
87	1·52854	1·6666	5·	
88	1·	1·093623	3·280869	
89	0·91391	1·	3·	
90	0·30578	0·3333	1·	
91	0·025368	0·02777	0·083	
92	0·019026	0·020833	0·0625	
93	0·012684	0·013888	0·0415	

A Reciprocal Table of Map Equivalents showing the number of inches of

No.	Scale.	1 Mile.	1 Kilometer	1 Chain.	1 Pole.
1	$\frac{1}{7349760}$	0·0086205	0·005359	0·00010775	0·00002693
2	$\frac{1}{2090880}$	·03030	·01882	·000378	·0000945
3	$\frac{1}{1267200}$	·05000	·03106	·000625	·00015625
4	$\frac{1}{1200000}$	·05280	·03280	·000660	·0001650
5	$\frac{1}{1013760}$	·06250	·03883	·000781	·00019525
6	$\frac{1}{1000000}$	·06336	·03937	·000792	·00019800
7	$\frac{1}{811008}$	·078125	·04854	·0009765	·0002441
8	$\frac{1}{760320}$	·08333+	·05177	·001041	·00026025
9	$\frac{1}{635000}$	·09979	·06199	·001247	·00031175
10	$\frac{1}{633600}$	·10000	·06213	·001250	·0003125
11	$\frac{1}{600000}$	·10560	·06561	·00132	·0003300
12	$\frac{1}{506880}$	·12500	·07766	·001562	·0003905
13	$\frac{1}{500000}$	·12672	·07874	·001584	·0003960
14	$\frac{1}{400000}$	·15840	·09842	·00198	·0004950
15	$\frac{1}{380160}$	·16666--	·10355	·002083	·00052075
16	$\frac{1}{375000}$	·16896	·10498	·002112	·00052800
17	$\frac{1}{316800}$	·20000	·12426	·00250	·0006250
18	$\frac{1}{300000}$	·21120	·13122	·00264	·0006600
19	$\frac{1}{240000}$	·26400	·16403	·003300	·0008250
20	$\frac{1}{200000}$	·31680	·19684	·003960	·0009900
21	$\frac{1}{190080}$	·33333+	·20711	·004166	·0010415
22	$\frac{1}{160000}$	·39600	·24605	·004950	·0012375
23	$\frac{1}{150000}$	·42240	·26245	·005280	·0013200
24	$\frac{1}{126720}$	·50000	·31067	·006250	·0015625
25	$\frac{1}{120000}$	·52800	·32807	·006600	·0016500
26	$\frac{1}{100000}$	·63360	·39368	·00792	·0019800
27	$\frac{1}{80000}$	·79200	·49210	·009900	·0024750
28	$\frac{1}{79200}$	·8	·497101	·01	·0025
29	$\frac{1}{76800}$	·82500	·51261	·010312	·0025780
30	$\frac{1}{63360}$	1·00000	·62130	·012500	·0031250
31	$\frac{1}{60000}$	1.05600	·65614	·013200	·003300
32	$\frac{1}{59400}$	1.066666	·662801	·013333	·00333
33	$\frac{1}{50000}$	1.26720	·78737	·01585	·0039625
34	$\frac{1}{40000}$	1.58400	·98421	·019800	·004950
35	$\frac{1}{39600}$	1.6	·994202	·02	·00500
36	$\frac{1}{39370}$	1·60934	1·00000	·020116	·0050290
37	$\frac{1}{38400}$	1·65000	1·02522	·020622	·00515550
38	$\frac{1}{38016}$	1·66666	1·03509	·0208333	·0052083
39	$\frac{1}{33792}$	1·875000	1·16537	·023437	·005859
40	$\frac{1}{30000}$	2·11200	1·31228	·026400	·0066000
41	$\frac{1}{25344}$	2·50000	1·55334	·031250	·0078125
42	$\frac{1}{25000}$	2·53440	1·57474	·031680	·0079200
43	$\frac{1}{23760}$	2·66666--	1·65692	·03333+-	·008333+
44	$\frac{1}{21120}$	3·00000	1·86403	·037500	·0093750
45	$\frac{1}{20000}$	3·16800	1·96842	·03960	·009900
46	$\frac{1}{19800}$	3·2	1·988404	·04	·010
47	$\frac{1}{19200}$	3·30000	2·05044	·04125	·0103125

Map and parts thereof, of the various scales now in use, which represent

No.	1 Metre.	1 Yard.	1 Foot.	Where Used.
1	·000005359	·00000489	·00000163	[(Military.)
2	·00001882	·0000172	·00000573+	Sherman's March Map.
3	·00003106	·0000284	·00000946+	" "
4	·00003280	·0000300	·00001000	U. S. C. S.
5	·00003883	·0000355	·00001183+	△ India.
6	·00003937	·00003600	·00001200	U. S. C. S.
7	·00004854	·00004438	·00001446	
8	·00005177	·0000473	·00001576+	R. R. Virginia.
9	·00006199	·0000566	·00001553+	U. S. C. S.
10	·00006213	·0000568	·000015600	U. S. Eng's.
11	·00006561	·0000600	·0000200	U. S. C. S.
12	·00007766	·0000710	·0000236+	Eng. Ord. Sur.
13	·00007874	·0000720	·0000240	U. S. C. S.
14	·00009842	·0000900	·0000300	U. S. C. S.
15	·00010355	·0000946	·00003153+	Ludlow's Rep.
16	·00010498	·0000960	·00003200	U. S. C. S.
17	·00012426	·0001136	·00003753+	Barnes' Pa. Map, 1851.
18	·00013122	·0001200	·00004000	U. S. C. S.
19	·00016403	·0001500	·0000500	U. S. C. S.
20	·00019684	·000180	·0000600	U. S. C. S.
21	·00020711	·0001893	·00006310	Ludlow.
22	·00024605	·0002250	·00007300	U. S. C. S.
23	·00026245	·0002400	·0000800	U. S. C. S.
24	·00031067	·0002840	·0000946+	Sherman's March.
25	·00032807	·0003000	·0001000	U. S. C. S.
26	·00039368	·0003600	·0001200	U. S. C. S.
27	·00049210	·0004500	·00015000	U. S. C. S.
28	·0004971	·0004545	·00015151	
29	·00051261	·00046875	·00015625	Geol. Sur.
30	·00062130	·00056800	·00018933+	Fremont.
31	·00065614	·000600	·000200	U. S. C. S.
32	·000662	·00060606	·00020202	
33	·00078737	·000720	·0002400	U. S. C. S.
34	·00098421	·000900	·000300	U. S. C. S.
35	·0009941	·0009090	·0003030	
36	·0010000	·0009144	·0003048	
37	·00102522	·0009375	·0003125	Geol. Sur.
38	·001035	·000947	·0003156	
39	·0011653	·0010653	·0003551	
40	·00131228	·0012000	·0004000	U. S. C. S.
41	·00155334	·0014190	·0004730	
42	·00157474	·0014400	·0004800	
43	·00165692	·00151515	·00050505	
44	·00186403	·0017040	·0005680	
45	·00196842	·0018000	·0006000	
46	·001988	·001818	·0006060	
47	·00205044	·00187500	·0006250	

A Reciprocal Table of Map Equivalents showing the number of inches

No.	Scale.	1 Mile.	1 Kilometer.	1 Chain.	1 Pole.
48	$\frac{1}{18818}$	3·36698	2·09206	·042087	·0105275
49	$\frac{1}{15840}$	4.0	2·485507	·05	·0125
50	$\frac{1}{15000}$	4·22400	2·62456	·052800	·013200
51	$\frac{1}{11880}$	5·33333	3·314009	·06666	·016666
52	$\frac{1}{10000}$	6·33600	3·93685	·079200	·019800
53	$\frac{1}{9900}$	6·4	3·976808	·08	·020
54	$\frac{1}{9600}$	6·60000	4·10088	·082500	·020625
55	$\frac{1}{7920}$	8·	4·971014	·10	·025
56	$\frac{1}{7200}$	8·80000	5·46784	·11000	·027500
57	$\frac{1}{6000}$	10·56000	6·561423	·132000	·033000
58	$\frac{1}{5940}$	10·6666	6·628018	·133333	·03333
59	$\frac{1}{5000}$	12·67200	7·8737	·15840	·039600
60	$\frac{1}{4950}$	12·8	7·953616	·16	·04
61	$\frac{1}{4800}$	13·20000	8·201770	·165000	·041250
62	$\frac{1}{3960}$	16·	9·942028	·2	·05
63	$\frac{1}{3600}$	17·6	10·93568	·22	·055
64	$\frac{1}{3333}$	19·00990	11·81173	·237623	·05940575
65	$\frac{1}{3168}$	20·	12·42434	·25	·0625
66	$\frac{1}{3000}$	21·12	13·122846	·264	·066
67	$\frac{1}{2970}$	21·33333	13·256036	·26666	·06666
68	$\frac{1}{2500}$	25·34400	15·74740	·31680	·079200
69	$\frac{1}{2400}$	26·40000	16·40354	·330000	·082500
70	$\frac{1}{1980}$	32·	19·88405	·4	·1
71	$\frac{1}{1280}$	49·50000	22·94414	·618750	·1546875
72	$\frac{1}{1250}$	50·68800	31·49480	·63360	·158400
73	$\frac{1}{1200}$	52·80000	32·80708	·660000	·165000
74	$\frac{1}{1080}$	58·66666	36·45231	·73333	·18333
75	$\frac{1}{960}$	66·00000	41·00885	·825000	·206250
76	$\frac{1}{840}$	75·42857	46·86726	·942857	·23571425
77	$\frac{1}{789}$	80·30418	49·89670	1·003802	·2509505
78	$\frac{1}{720}$	88·00000	54·67847	1·100000	·275000
79	$\frac{1}{600}$	105·60000	65·61416	1·320000	·33000
80	$\frac{1}{500}$	126·72000	78·73700	1·584000	·39600
81	$\frac{1}{480}$	132·00000	82·01770	1·650000	·412500
82	$\frac{1}{360}$	176·00000	109·35694	2·2000	·550000
83	$\frac{1}{300}$	211·20000	131·22833	2·640000	·660000
84	$\frac{1}{240}$	264·00000	164·03541	3·300000	·825000
85	1/15[illegible]	420·	198·8405	4·	1.
86	$\frac{1}{120}$	528·00000	328·07083	6·600000	1·65000
87	$\frac{1}{60}$	1056·00000	656·14166	13·20000	3·3000
88	$\frac{1}{39.3704}$	1609·330	1000·	20·11663	5·02916
89	$\frac{1}{36}$	1760·	1083·5694	22·	5·5
90	$\frac{1}{12}$	5280·00000	3280·7083	66·00000	16·5000
91	$\frac{1}{1}$	63360·00000	39368·5000	792·0000	198·000
92	$\frac{4}{3}$	84480·00	52491·0333	1056·000	264·000
93	$\frac{2}{1}$	126720·00	78737·0000	1584·000	396·000

Map and parts thereof, of the various scales now in use, which represent

No.	1 Metre.	1 Yard.	1 Foot.	Where Used.
48	·00209206	·0019130	·0006376 +	U. S. C. S.
49	·002485	·002272	·0007575	
50	·00262456	·0024000	·0008000	U. S. C. S.
51	·003314	·0030303	·0010101	
52	·00393685	·0036000	·0012000	U. S. C. S.
53	·003976	·003636	·001212	
54	·00410088	·00375	·0012500	
55	·004970	·004544	·0015150	
56	·00546784	·005000	·001666 +	
57	·0065561423	·006000	·002000	
58	·006628	·0060606	·0020202	
59	·0078737	·007200	·002400	U. S. C. S.
60	·007952	·007272	·002424	
61	·008201770	·0075000	·002500	
62	·00994	·009088	·003030	
63	·0109356	·01	·003999	
64	·01181173	·0108010	·003603 +	U. S. C. S.
65	·012424	·0113181	·0037727	
66	·0131228	·012	·004	
67	·013256	·0121212	·0040404	
68	·01574740	·014400	·0048000	U. S. C. S.
69	·01640354	·015000	·005000	U. S. C. S.
70	·0218712	·02	·007999	
71	·02294414	·0281250	·0093750	U. S. C. S.
72	·03149480	·028800	·0096000	U. S. C. S.
73	·03280708	·030000	·010000	U. S. C. S.
74	·03645231	·03333 +	·0111111 +	
75	·04100885	·037500	·012500	
76	·04686726	·0428547	·0142849	
77	·04989670	·0456273	·0152091	
78	·05467847	·050000	·016666 +	
79	·06561416	·060000	·020000	
80	·07873700	·072000	·024000	U. S. C. S.
81	·08201770	·075000	·025000	
82	·10935694	·100000	·033333 +	
83	·13122833	·12000	·040000	
84	·16403541	·150000	·050000	
85	·218712	·2	·079999	
86	·32807083	·30000	·100000	U. S. C. S.
87	·6561416 +	·600000	·200000	
88	1·	·914392	·304464	
89	1·093569	1·	·333333	
90	3·2807083	3·00000	1·0000	
91	39·39850	36·0000	12·0000	
92	52·49103 +	48·00000	16·0000	
93	78·737000	72·0000	24·0000	

VIII.

THE STRENGTH OF WROUGHT IRON IN STRUCTURES.

By Percival Roberts, Jr., Member of the Club.

Read Oct. 19th, 1878.

The subject to which I would invite your attention this evening is the strength of wrought iron used in construction. In ancient times philosophers and poets were wont to style the age of iron as one inferior both to that of silver and the brighter one of gold. Now all is changed, and the nations of to-day are ranked in the scale of civilization in proportion to the amount of iron consumed by each individual member. In former times the application of iron in construction was limited, and was made by guesswork of routine.

An anecdote once told me by a foreigner well illustrates this period, which I trust is forever past. A young German, a university graduate, obtained a position in one of the prominent machine shops of England. Soon after entering upon his duties he was given some heavy piece of machinery to design. Upon this he started, and while engaged in calculating the strains and necessary strength of the various parts he was asked by one of the proprietors what all that "stuff" (as he was pleased to term it) was for. Upon being told, he exclaimed: "All nonsense; we don't work that way here. Go build the machine, and when finished start her going. If she smashes up we shall know what parts are too weak, and if she goes, all right." This, I fear, has until recently been the practice, not only with machinists, but with too many who, under the great palladium of civil engineer, have palmed upon the public their wares in the shape of unsound bridges, and their empiricism has only been made apparent by some awful crash and the investigating labors of a coroner's jury. At the present day a much better era has been entered upon. The once depised theory is now both the handmaiden and the guide to the formerly all-powerful practice. With the aid of

mechanics and the higher mathematics, with strain tables, etc., to guide him, the engineer of to-day goes about his work by no means so blindly as he of a previous generation. But in all these calculations it is of paramount importance—nay, an absolute necessity—to have very accurate data as regards the strength of the material to be used. Iron, of which so much is known and about which so little is understood, takes the foremost place among the constructive materials of the present day, and concerning what has already been done, rather than any new theories, shall I make a few remarks this evening. A very unfortunate circumstance is connected with all the earlier experiments upon the subject, namely, that while we have no lack of tabulated statements giving the number of pounds required for tearing asunder and compressing a piece of wrought iron, we are left entirely in the dark as regards the methods employed and the shapes and sizes of the specimens operated on, upon which everythings depends.

Mr. S. Hughes, writing for the *Artisan* under date of February, 1858, well sums up in the following sentences the knowledge then possessed concerning the strength of iron: "There is probably no branch of experimental inquiry in which more varying and discordant results have been attained than in that which seeks to determine the absolute strength of wrought iron subjected to a tensile strain, or to the action of a weight applied to tear it asunder." It may be well to remark that the above discordant results varied between the limits of 90,000 pounds and 50,000 pounds per square inch for the ultimate tensile strain —truly no very comfortable data upon which to base one's calculations. In the year 1864 appeared a volume of some 200 pages and 16 plates, published at Glasgow, entitled "Results of an Experimental Inquiry into the Tensile strength and other Properties of Various Kinds of Wrought Iron and Steel," by David Kirkaldy, undertaken for the Messrs. Napier & Sons, and further enlarged upon at the instigation of the Scottish Shipbuilders' Association—a volume which to-day is out of print; yet the investigations and conclusions therein recorded live in almost all the works of later writers upon this subject. Mr. Kirkaldy, at the outset, with great good judgment, perceived the errors of

his predecessors and endeavored to avoid them, especially by giving the fullest details in regard to experiments, even at the risk of becoming tedious and uninteresting. His conclusions no doubt are familiar to all, so that I shall mention but few of the more important ones, prominent among which is that arrived at concerning the shape of the test piece with reference to the tensile strength obtained. He found that if a bar, instead of being of parallel section, be turned down by sinking a fillet into it so that a minimum section occurs at but one point, that specimen would stand a much higher strain before breaking than a piece from the same bar whose section was parallel, the former contracting none whatever at the point of rupture, while the latter would be much reduced. The mean of 14 experiments gave on the grooved section, 73,942 pounds per square inch, while the same bars not grooved showed but 62,256 pounds per square inch, a difference of 11,686 pounds in favor of the grooved section. He also pointed out the importance of taking into account the reduction of area of specimen, and sums up the results of his experiments in a set of sixty-six conclusions. The book is full of interest and will well repay perusal. Mr. Kirkaldy, however, made one error in a point which he endeavored to guard against, namely, in omitting sufficient mention of the sizes of the iron from which his test pieces were taken, and his results, which are for the most part rather too high for ordinary iron of moderate dimensions, lead us to conclude that the bars from which his test pieces were taken were of the very small sizes. I will not mention the labors and results of Fairbairn in England, or of the investigators on the Continent, for time will not suffice.

To test correctly, a fundamental requisite is the reliability and fitness of the testing machine employed. Since the days of Kirkaldy's experiments many improvements and new machines have come into existence. The plain and cumbrous lever, with its huge load of weights, has made way for more complicated, but I cannot say more accurate, machines, among which may be mentioned the one using a hydraulic jack, the weight being registered through the pressure in the cylinder; also the screw machine, where force is obtained by means of a powerful screw. But

in almost all these the varying amount of friction, whether in the hydraulic packing or the screw, introduces so great a factor of uncertainty as to make the machine utterly worthless. There is at the present time a testing machine built by the Messrs. Riehlé Bros. of this city, which with its latest improvements seems to come up to all the requirements we may need. The force is applied by means of a hydraulic jack worked by three pumps, which are driven by power, the object of the three being to always have one in action, so that the strain be evenly applied and not by jerks, which is the case where a lever and two pumps are employed. The strain applied is weighed upon a beam attached to the other end of the specimen, so that we get without doubt the actual force acting upon the piece. One point in their machine, however, I feel that I cannot too heartily condemn, namely, their method of grasping the test piece by steel wedges with roughened surfaces, whereby distortion of specimen takes place, and I cannot help thinking that the strain in many cases is not transmitted parallel to the axis of the bar, giving results which are not strictly correct. And to-day, when so much iron must be guaranteed as regards strength, and where a difference of a few hundred pounds may reject or admit a specification of many tons, we cannot be too careful in the methods employed.

Until very recently, experiments in this country upon the strength of wrought iron for constructive purposes have been conspicuous for their absence. It is true, very complete investigations had been carried on by officers of the Ordnance Department upon the fitness of various metals for the manufacture of cannon, yet for ordinary uses little was known except what was gleaned from English works and English conclusions upon English irons, which in many instances are entirely dissimilar from American brands. When specifications for bridges were given out it was frequently made a condition that such and such members should be made from certain brands of English scrap, which were believed to be far superior to anything manufactured in this country. Lately, however, we have awakened to the necessity of a full and complete knowledge concerning the qualities of our own American products of iron and steel, and the testing machine which to-day stands unfinished in the Watertown

Arsenal is a monument alike to American genius and mechanical skill, and a disgrace to the short-sighted economy of her representatives in office; for were it but completed it would be the most powerful and accurate machine in existence, capable of testing the longest and largest bars in their natural condition. An abstract by Mr. Holley, one of the members of the United States Commission for testing iron, steel, etc., of the results obtained by the section appointed for testing iron for cables, which has appeared during the present year, gives some very interesting conclusions drawn from their work, which embraced over two thousand tensile tests, each showing elastic limit, elongation and reduction of area; also 42 complete chemical analyses in connection with the above physical tests. The great difficulty, however, which occurs with all quantitive chemical analyses upon the subject is, that when wishing to observe the effect of any one constituent in varying proportions it is impossible to keep the remaining elements unchanged; for instance, to hold phosphorus, sulphur, silicon, etc., at a fixed percentage, while carbon is placed in the ascending or descending scale; for I can say confidently that with all care no two heats of iron, nay no two bars in the same heat, from the same puddling furnace, worked by the same men, will be similar in their chemical composition. Among the more important conclusions drawn in Mr. Holley's paper is the connection between tensile strength and reduction of area of pile by rolling—namely, other things being equal, the greater the section of pile the greater the strength of bar rolled from it. This fact, although known, I am certain, to some manufacturers, appears for the first time upon record in the labors of this commission, and has already borne very good fruit, as may be shown by the following quotation: [1] "In accordance with the facts, the United States Test Board has shown by trial the unsafety of the admiralty proof tables for chain cable, and has prepared new ones, and also new tables of the strength of different sized bars. The board has demonstrated the tenacity of 2-inch bar for chain cable should be between 48,000 and 52,000 pounds per square inch, and of 1-inch bar

[1] The Strength of Wrought Iron as Affected by its Composition and by its Reduction in Rolling. By A. L. Holley, Ph. B., 1878.

between 53,000 and 57,000 pounds." A fact, I am sure, at which every one will rejoice who has ever attempted to comply with the former too high specifications. Allow me to give the conditions required by the Pennsylvania Railroad Co. to be fulfilled by iron to be used in its bridges, as representing the average specifications of the present time; and with a few remarks upon the same, I shall bring this too rambling paper to a close. The requirements are as follows: "All the wrought iron must be of the best quality, tough and fibrous, free from flaws and injurious cracks along the edges. All the iron in the tensile members, lower chords, tension diagonals, laterals and bolts, must be double rolled from the muck bar direct; no scrap will be allowed [and must be capable of sustaining an ultimate stress of 60,000 pounds per square inch on a turned down or grooved section, with no permanent set under 25,000 pounds per square inch]. Wrought iron will also be acceptable upon the following modifications of that part of the specifications inclosed in brackets, and must be capable of sustaining an ultimate tensile stress of 50,000 pounds per square inch on a full section, with no permanent set under 25,000 pounds per square inch, and with a minimum stretch of 20 per cent. under ultimate stress."

I consider the test piece with groved section as utterly worthless for any information which may be required concerning the material under examination. It represents an entirely artificial condition, and one which rarely if ever occurs in practice. An iron which would fill the above requirement in all respects might be utterly worthless for tension purposes, very hard, with low limit of elasticity and no ductility whatever. Upon no consideration would I allow iron for any purpose to be tested by the above method. On the other hand, the parallel section represents the natural manner in which the material, for the most part, is used; from it elastic limit and ductility may be obtained, two things about which we know nothing in the first method. To ascertain the limit of elasticity very accurately is surely of more importance than to have the tensile strength to within a few thousand pounds; for, strain a piece beyond this limit and no matter what its ultimate strength may be it is but a question

of time when rupture will ensue. A soft iron, admirably adapted for resisting shocks, may have an excellent limit of elasticity, great ductility, and yet may not come up in ultimate strength to an iron in every respect much its inferior, so that I think if our factors of safety were only proportioned to the elastic limit, rather than to the ultimate strength, much safer and more accurate results would be obtained than by the methods now employed. Too many seem to be governed by the motto "Safe if unbroken." Again, a few words occur in the specification the importance of which is not generally recognized, nor are their requirements always enforced. For tension members they say all iron "must be double rolled from the muck bar direct." It is not sufficient that the bars stand the required pull, but that they must be double worked; the additional factor of safety which is added by so doing is more than is usually believed. Every time a bar is reduced and repiled with other bars, so much less is the risk of having a finished bar composed of a number of pieces of poor iron. I would urge upon engineers the extreme importance of this point, that they do not, by reason of a mistaken economy, jeopardize the lives and happiness of many thousands of people, rather than pay the slightly increased cost which this double working will entail. It is now much too often only required that the bars stand such and such a pull, no further stipulations being made. In regard to the strength required when the bars are too large to be tested in a natural state, shall test pieces be cut and turned from them, or shall the same iron be rolled, say, into an inch round and tested in original section? For the manufacturer the latter would be much the more fair of the two, for by the time a piece is taken, for instance, from a 7 inch by 3 inch flat, intended for an eye bar, turned and planed down into a test piece of probably $\frac{3}{4}$ inch diameter, it does not represent the quality of the whole; nay, it matters considerably whether the test piece be cut from the front, middle, or back part of the bar; that from the front of the bar will give higher results than one taken from the back part, when the bar is worked upon a two-high train of rolls, owing no doubt to the inclosed cinder being worked toward the last end of the bar which passes between the rolls. If there were testing ma-

chines strong enough to take a bridge member direct, it would be the only proper and pre-eminently just manner in which iron should be tested, but until those machines are forthcoming I think the other method of preparing test pieces should be adhered to. In conclusion, let me urge upon you the importance of frequent and accurate tests; buy no iron from any man without tests of the same. It will stimulate manufacturers to greater carefulness in the preparation of their products; a higher class of goods will be placed upon the market, and structures will arise concerning the safety and stability of whose material no one can question or doubt.

REPORTS OF COMMITTEES, ETC.

I. On the Metric System of Weights and Measures.

Presented April 6th, 1878.

To the Engineers' Club of Philadelphia:

The committee to whom was referred the communication and circular received from the Boston Society of Civil Engineers, asking the co-operation of the Club (a) to secure unanimity of action among the engineering professions, toward introducing the Metric System of Weights and Measures, and (b) to petition Congress for such legislation as may procure its universal adoption in the United States, respectfully begs to report:

That as the subject of the advantages of the several systems of weights and measures employed by different nations, has been so copiously considered during the past decade, by national and international conventions and by scientific societies throughout the world, your committee has not thought it advisable to discuss anew the merits of the several systems proposed, but have availed themselves of the existing literature and have based their report thereon.

First. They recognize in the Metric System of Weights and Measures the most desirable system of notation, either for theoretical computation or for measurements in the sciences and practical arts.

Second. They would heartily recommend the use of this system to all scientific and practical men; they advise its free introduction into all original literature bearing directly on professional work, recommending the conjoint use of the English notation

with it, in order to familiarize the public with its practical utility, which, if accomplished, will constitute one of the most important means for its final and universal adoption.

Third. They would also recommend its gradual introduction into machine shops and in all practical work wherever possible.

Fourth. They would request that, in all papers read before the Club, the Metric System be used conjointly with the English, and that on all maps, sections and drawings a metric scale be placed, for comparison with the ordinary mile, foot or inch scale.

Fifth. The committee deprecates the immediate compulsory adoption of the Metric System by State or National legislation, and considers that it would be a work of supererogation to attempt to compel any class of men, either technical or practical, to adopt it to their personal or pecuniary loss.

Sixth. They recognize the compulsory education of the children in our public schools in the Metric System as one of the most important means toward its ultimate adoption, and would recommend to the State and municipal authorities throughout the United States, the enactment of such legislation as shall make the system familiar to the working classes.

Seventh. In conclusion, your committee heartily approves of the establishment and maintenance of the permanent International Bureau of Weights and Measures (*Bureau International des Poids et Mesures*), at Paris, with the object of promoting permanence, precision and uniformity in the standards, at the proportional expense of the contracting governments, and considers it of the highest importance that such appropriations should be made by Congress as shall secure for the United States a permanent representation.

Respectfully submitted by the committee:

RUDOLPH HERING,
WM. D. MARKS,
COLEMAN SELLERS, JR.,
HENRY C. LEWIS,
CHAS. A. ASHBURNER,
Chairman.

After the reading of the report the following resolutions were offered by Mr. Wm. F. Sellers, and, upon motion, were adopted:

Resolved, That the report of the committee be accepted, and that it be incorporated in the minutes, with a record of the vote of the members.

Resolved, That the report be printed in legible form to be distributed among scientific societies, public institutions and authorities, asking co-operation to bring about the desired change in the system of weights and measures.

II. Memorial to Congress in behalf of the U. S. Board for Testing Iron, Steel and other Metals.

Presented May 4th, 1878.

To the Senate and House of Representatives of the United States in Congress assembled:

The Engineers' Club of the City of Philadelphia respectfully petition your honorable bodies to continue the appropriation to the United States Board for Testing Iron, Steel, etc., and urge in support of such request the following reasons:

1. *The object is important.* Those conversant with constructive works are aware, in a greater degree perhaps than the general public, of the immense ignorance existing in regard to the strength of materials. All the tables and rules relied on by engineers are based upon experiments made long ago, and made without regard to the chemical composition of the metals. Besides, these tests were made with what may be called miniature pieces of metal, while nothing is more certain than the fact that iron or steel in large masses differs in strength very greatly from the same metal in small test pieces. Moreover, all the published tests from which the rules are deduced were made with foreign materials—no systematic tests of American iron having ever been made, except for ordnance purposes.

Since then the whole world of constructive mechanics has been revolutionized by the cheapening of steel, which has made this a practical material of construction. Its use has increased enormously for every purpose in the mechanic arts, from ship and boiler plates to bridges, and yet we know almost nothing about the variations in the properties of steel.

2. *The object is national.* In a matter of such universal application the whole country is interested. Every one, for instance, travels by land or water, and is concerned in the question of the safety of bridges and boilers.

And yet it cannot be expected that private persons or scientific associations should be able, however willing, to expend the considerable sums of money required in a thorough investigation of the kind proposed. Nor would the same confidence be placed in results so obtained as would be given to those over which the government exercised direct control. Unless it is undertaken by the nation for the nation it will not be done at all. And surely a nation which has always been most liberal towards purely scientific objects—which has spent its hundreds of thousands in geological and astronomical work, will not hesitate to devote a moderate sum to a purpose of such immense importance.

3. *The continuance of the Commission is economical.* The appointments made have been eminently satisfactory to the public. The Commission have gone through enormous preliminary labor, and have cleared the ground for effective work. They have directed the construction of a machine, the largest in the world, now almost completed, for the purpose of testing bars of the full size used in actual practice. They are now prepared to work efficiently and rapidly.

If Congress now refuse the appropriation, and the Commission is dissolved, all this labor will be lost, and a new commission would have to go through the whole preliminary work again. Meanwhile the cost to the country, both from the use of unnecessary material in construction, and, which is worse, from the losses and accidents caused by the use of too little material, in obedience to the old rules, will for every day of such delay amount to more than the total appropriation asked for the Commission.

And your petitioners will ever pray, etc.

Committee to prepare memorial:

WM. A. INGHAM,
Chairman.
J. S. BANCROFT,
PERCIVAL ROBERTS, JR.

III. MEMORIAL TO THE LEGISLATURE OF PENNSYLVANIA, IN BEHALF OF A GEODETIC SURVEY OF THE STATE.

Read October 19th, 1878.

To the Senate and House of Representatives of the State of Pennsylvania, in Legislature assembled:

The Engineers' Club of Philadelphia, and the undersigned residents of the State of Pennsylvania, respectfully petition your most honorable bodies to enact such laws as will provide for a thorough Geodetic Survey of the State, and the accurate and permanent location of all county and township lines; and urge in support of such request the following reasons:

1. *The demand for such work is imperative.* Those conversant with the various maps of the State and of the several counties, are aware, in a much greater degree than the general public, of the very gross errors which abound in the location of important boundary lines, roads, streams, etc. The need for more accurate data has been keenly felt by every engineer and geologist in the State who has attempted to make use of existing maps.

The following extract from the Preface by the State Geologist

to Report of Progress Q, shows how much the absence of correct maps has been felt in the prosecution of that work: "I regret, more than I can express, the imperfections of these maps. They neither fit on to each other, nor correspond to any common standard map. In fact, there is no such standard map in existence. There are county maps, some of them very old, out of print, and impossible to obtain except by loan from their owners; and there are others of later date; but none of them, old or new, are of any scientific value. There are also county atlases, made up of township maps, none of which can be made to fit together at their edges; and small county maps which are constructed and executed in so faulty a manner, that the geologist and the engineer who attempt to use them are thrown into despair.

"With these imperfect guides the Geologists of the Survey have been obliged to content themselves. . . . . Nor will this scandal to our geology be removed until the Legislature organizes a scientific topographical survey of the State.

"The United States Coast Survey has indeed begun a regular triangulation of the State, and promises to provide us with at least one absolutely sure position in every township of every county. But its means are so limited that this great work moves on very slowly, and, unless State appropriations are made to hasten it, may occupy twenty to thirty years."

* * * * * * *

"It is evident the Geological Survey cannot wait for all this to be done. It must therefore use the almost worthless maps—county maps and township maps—which exist, rudely run as their lines have been by irresponsible men, on cheap money contracts, rapidly and carelessly plotted afterwards, and finally forced together recklessly and without judgment, so as to come within county lines which are themselves utterly false and oftentimes half-a-mile away from their true places. Even the northern line of the State itself is found this year to be wrongly located at every point, so far as the new survey of it by the United Commissioners of New York and Pennsylvania has advanced its stations. To add to the confusion, the township and county maps thus falsely drawn have been still further falsified by a fresh set of errors inevitably connected with publication."

2. *Correct maps are indispensable to the proper development of the State.* Every one of the European nations have recognized the value of trustworthy maps, and have organized surveys upon broad, liberal foundations. This commonwealth, so rich in mineral and agricultural wealth, should most certainly not be satisfied with the miserable make-shift prints which at present repre-

sent our knowledge of the topography of the State. Owing to our thorough system of public education, the increasing intelligence of the masses demands an accurate knowledge of this portion of the earth's surface; a surface which, though slightly modified by man's action upon it, yet retains the same principal features from age to age, so that one *good survey*, with slight occasional corrections, will suffice for an indefinite period.

The results of such surveys as the Ordnance Survey of Great Britain, and the thorough geodetic and topographical surveys of the several countries of Europe, are of incalculable value to every member of the respective communities.

Thoroughly accurate maps are *indispensable* to the correct representation of the geology of a country: they are a *very material aid* in the preliminary location of railroads, canals, river improvements, mines and the various industrial works; they can be made a wonderfully accurate index to the wealth and resources of the State by representing upon them the areas of arable land, of the various kinds of forest, of coal and iron, etc.; by using a large scale they can be made to serve still another purpose, by giving the areas of all estates and the position of boundary lines with sufficient accuracy for the imposition of taxes, and may even be made a basis for land titles.

3. *Reform needed in land surveying.* The Honorable Secretary of Internal Affairs, in each of his Annual Reports for '75, '76, '77 and '78, has called attention to the urgent need of a reform in the methods of land surveying. Though such a reform is of the utmost importance and is sadly needed, it cannot be accomplished until accurate and reliable meridians and standard measures are established in every township of every county in the State.

The following extracts from the reports mentioned will probably give a better idea of the needed reforms in Pennsylvania, than any general statement could convey and establish the fact that such a reform cannot possibly be accomplished until we have some accurate base-work to which to refer all minor surveys, land lines, etc.:

" In the early days of the commonwealth the surveyor always preceded the settler. His work was done in the forest, often with few and inexperienced assistants; he had to contend with the inclemencies of the weather, impassable streams and swamps, and not unfrequently was in danger from the Indians. Besides all these difficulties which beset the earlier surveyors, who were generally competent and skillful men, during the several land speculating manias which took hold upon our people, when orders and warrants were issued by the hundreds daily, . . .

large tracts of country were hastily and imperfectly surveyed by careless or unskilled artists, and great errors were committed; hence the lines represented on the returns, and perpetuated in the patents, differ materially from those marked upon the ground. These errors the owners would be glad to correct where the original evidences of boundary yet remain. As long as landmarks exist, and can be verified by the usual tests, disputes seldom arise. Corner or line trees may decay, or be burned or cut down, and other marks destroyed or removed. Against the disputes generally following these contingencies, the landholder should be protected by the authorization of a correct survey, and a record of its metes and bounds.

"Such a survey would also prove of great value to the members of the bar in assisting them to remove the ambiguities that frequently arise under the present method of marking and describing lines. Now, even with the assistance of experts and "practical surveyors" it is often impossible to determine the original location of boundary lines and the case must be compromised.

"A re-examination of the surveys of *county and township lines*, turnpike, State, township and other roads, reveals even a *greater degree of inaccuracy* than is found in our land surveys, rendering it difficult and, in some cases, almost impossible to recover the original location. * * * * * *

"In 1876, a circular letter was prepared, in which the matter was more fully elaborated, and was addressed to the President, Judges of a number of districts, to each County Surveyor in the commonwealth, and to other persons. The replies received furnish evidence showing that the Act of 1850 has been wholly ignored in some counties; in others, the true meridian lines are so contiguous to local attraction as to be worse than useless; and that, in some counties, the surveyors either wholly neglect to make their tests, or perform them out of season, or omit to make the required record of observations."

Mr. Platt, C. S., of Erie, says: "There are very few landmarks left in this county in comparison to the number that at one time no doubt existed.

"The tests by measurement cannot be relied upon, for the reason that the tracts are in excess of the same, and the surplus is not uniform, land here in many cases over-running the quantity called for by the old deeds, to the amount of ten and fourteen per cent. beside the six per cent. allowance for roads, etc.

"I would suggest that if we *must* use the *needle*, that each township should have its own meridian at or near its centre.

"The next best thing to do is to abolish the use of the needle entirely, and establish base-lines for each township and city, and

have them laid down and recorded by the true astronomical course, and all surveys made by triangulation from that line.

"Surveying is as much a profession as medicine or the law, and no person should be allowed to practice it without authority, any more than a lawyer should be allowed to practice in our courts without being admitted to the bar.

"*I think that if the whole State could be re-surveyed by means of triangulation, that what would be gained by re-assessment and saving of vexatious litigation would more than pay for the survey; of course, we cannot change old landmarks, but we can record them as they are, and give correct areas bounded by such.*"

Mr. John B. Kaufman, of Franklin County, in his reply to the circular, says: "I have often thought, too, that great advantages would be derived from a system of triangulation over the State, covering the several counties with a network of lines and angular points at convenient distances, the lines to be of moderate length, their directions and lengths accurately determined, the angular points plainly and permanently marked, so that all lines, or the most important lines, might be referred to such lines or points, the whole to be recorded in such a manner as to be easily accessible to all surveyors." * * * *

The Report of the Pennsylvania Board of the Pennsylvania and New York joint Boundary Commission, for 1877, contains some valuable information in regard to their work.

At the eastern end of the line, separating the two States, "most careful search was made for the initial monuments of the old surveyors, without success, and the only means left to ascertain the approximate locality, was to explore westwardly, find the first piece of the old line remaining unchanged, and produce that eastwardly to the point where it intersected the thread of the main channel of the Delaware."

"Of the meridianal boundary which separates a portion of Erie County, Penn., from Chataqua County, N. Y., we have been given to understand, by very high authority, there is scarcely a mark remaining."

"During our study of this important subject, our attention has been necessarily drawn to the admirable methods of the Coast Survey, in this and relative regards. Their work proves itself, and, wherever it has been done, its benefits have been felt and appreciated. We cannot help thinking that the area of its operations should be extended, so as to embrace the interior, as well as the seaboards, of the States. Its lines of precision, permanently marked upon the surface of the land, would be of infinite advantage. The multitudinous causes of land disputes would soon arrange themselves, by reference to the exact demar-

cations left by this admirable corps of surveyors. The thousand and one errors of the magnetic needle, in Pennsylvania, especially (owing to the mineral character of so much of her soil), more momentous than elsewhere, would cease to cause the bitterness and jealousies of ejectment suits, and in a short time the surface of the State would be as well known to all, as the most careful plot of a farm or village is now known to its proprietors or citizens. It is to be hoped that no more time will elapse before the proper authorities shall provide for a correct topographical map of the State. It is difficult to enumerate the substantial benefits which would accrue to the people from such a course. Other States are directing attention to this subject, and wondering, as they advance, why it was they had put the matter off so long. Let Pennsylvania not be behindhand in this good work."

4. *Organization of the Survey.* It should be under the control of a Board consisting of the Governor, the Secretary of Internal Affairs, and an appropriate number of representatives and competent citizens, to be appointed by the Governor. The Director of the Survey, elected by the Board, should be required to submit his plans and estimates to them for approval.

The number of field parties, size and duties of the same, must of course be influenced by the amount of the appropriation, and depend upon the judgment of the Board.

It is suggested, however, that the law should be so framed as to allow of detailed topographical work being pushed to completion in the more wealthy and thickly settled counties, provided that each county bear half the expense of the detailed work, the triangulation work being provided by the State.

In order to meet the very great necessity for more uniform returns to the Land Department from the several county surveyors and others, it would be well to provide for the organization of one or more parties, to be under the supervision of the Director of the Survey, whose duty it should be to establish and permanently mark, in every township in the State, a true meridian and standard chain length.

"Such a plan, giving at once final accuracy in the controlling points, and permitting of indefinite extension in the representation of detail around them, furnishing a skeleton to which local surveys could be fitted till the whole was complete, would at least supply us with maps of our State that would be creditable and that could be compared with those of other civilized nations."

5. "Owing to the character of such a survey as the one proposed, it can only be prosecuted economically and satisfactorily by means of the State authority, and must necessarily depend upon appropriations from the State government.

6. "It is certainly the experience of foreign countries, including several less wealthy than our own State, that these surveys are many times more valuable than their cost, in the aid which they afford to the carrying out of internal improvements, to the equalisation of taxes, and to many of the necessary operations of general and municipal government, as well as to private individuals."

7. *At present a survey can be prosecuted economically and to great advantage.* The Honorable Members of the Pennsylvania Legislature should not fail to recognize the very important advantages which would accrue to every department of the State government and to the welfare of all the citizens of the Commonwealth, from the results of the survey. And owing to the very wise and liberal laws enacted by Congress in 1871, authorizing the Coast Survey to extend its system of triangulation over any State in which Scientific Surveys were provided for, the present is the most fortunate time for the prosecution of geodetic work in our State.

Triangulation work, if once well done, is done forever; and it is very much more economical not to do it all, than to do it badly.

And your petitioners will ever pray, etc.

Prepared by CHARLES E. BILLIN,
Secretary.

This memorial was signed by a large number of prominent citizens of the State, and is now pending (February, 1879.)

NOTES AND COMMUNICATIONS.

SOUTH STREET BRIDGE.

MEETING, FEBRUARY 16TH.—A paper on the "South Street Bridge," by Prof. L. M. Haupt, was read. Estimates of the pressure on the piles forming the foundations for the piers in the western approach had been calculated from data obtained from drawings in the office of the City Engineer. Prof. Haupt thought that, as the piles were driven through or into soft mud, which is inundated at every tide, the pressure placed upon them was in excess of their bearing power in such soil, and the cause of the fall of the structure. This paper brought out very general discussion.

Mr. Geo. Burnham, Jr., gave a general description of the masonry work of the bridge, and presented a plan which, if used, might have saved part of the structure. At the second pier east of the Pennsylvania Railroad, the piles were driven through fifteen feet of mud to a bed of gravel. Only the north end of this pier sank, the south end remaining firm.

Mr. D. McN. Stauffer stated that at the railroad abutment the gravel bed was within a foot of the surface—only one hundred feet west of the failing pier; it seemed to have a regularly sloping surface from this railroad abutment towards the river, where the piles were driven through forty-five feet of mud before reaching the gravel. Piles were all driven with a 2,000 pound hammer, and received, as a final test, four blows from the hammer with thirty feet fall, when one inch downward motion was the maximum allowance for each blow. The cause of the failing of the pier is not known, and cannot be definitely stated until examinations have been made. The fact that within twenty-four hours of the final crash there was not a single vertical crack in the masonry, though the pier was sinking at one end only, proves that the grillage must have been perfect. The estimated load on the piles under the pier was 2,000 tons, amounting to twenty-three tons on each pile. According to rules given by Rankine, for pile-work under similar circumstances, each pile was good for eight tons frictional value, leaving fifteen tons on the toe of the pile. The tremor produced in the piles by travel on the bridge would gradually loosen them sufficiently to allow the percolation of water down their sides, and finally throw the *whole* weight on the toe of the pile. If the bed of gravel was merely a thin bed or pocket, as the water softens it, the additional weight, before sustained by friction, probably allowed a bunch of piles at the north end of the pier to settle down into softer material beneath the gravel. Some theory of this kind must be advanced to explain why the structure remained stable for nearly six years before the final catastrophe. Every block of coping, paving, etc., in the roadway above had, by the sinking of the pier, taken the form of an inverted arch, and helped to convey weight to the sound piers on either side, and that their removal threw the additional weight on the failing pier. An expenditure of $500 in tying together the adjoining arches at the springing line would have saved seven out of the nine. If time had permitted the putting in of centres on the plan proposed, they would have been of little value without similar tie rods.

Mr. R. Hering did not think the removal of the roadway above the sinking pier was a disadvantage, because the cracks in the pavement

showed that *no* horizontal pressure was transferred. It would therefore only have acted as dead weight.

MEETING, APRIL 6TH.—Mr. D. McN. Stauffer made some additional remarks concerning South Street Bridge. Borings had been made about twenty feet distant from each end of the failing pier. At the south end, which did *not* sink, gneiss rock was found 33′ 8″ below the surface of the marsh. The rock was overlaid by eighteen to twenty inches of gravel, and then a considerable thickness of a hard, very compact yellowish clay. At the north end, which failed by sinking, the rock is thirty-seven feet below the surface. Above the rock is 3′ 8″ of black mud, and above this about seven feet of gravel mixed with clay. This tongue of mud, running under the north end of the pier, was doubtless the cause of the trouble. The piles were driven nearly through the gravel stratum, friction of the materials resisting further driving. Lubrication of the piles by the slow percolation of water, aided by the vibration of the structure, would destroy the frictional value due to the tough mud, and throw additional weight on the toe of the pile, probably loaded to its full bearing value. Supposing this to have been the case, with a yielding material under the gravel stratum, sinking was inevitable.

KENTUCKY RIVER BRIDGE.

MEETING, MAY 4TH.—Mr. William F. Sellers read an interesting paper on the Kentucky River Bridge. The paper was illustrated by large photographs of the structure and by working drawings. The Cincinnati Southern Railway crosses the Kentucky River at a point where several years ago four stone towers were erected by Mr. Roebling. The structure for which these were intended was never completed. The river at this point is about 300 feet wide, and flows in the bottom of a narrow canon about 300 feet deep and 1300 feet wide. For numerous reasons a pier in the river was rendered impracticable, so it was decided to use three spans of 375 feet each. These were erected without the use of any false works, which the great height of the bridge and the swift current of the stream precluded. Though a continuous girder in three spans would have fulfilled all of the conditions necessary during erection, yet the fact that the iron piers would vary in height with the temperature, while the cliff abutments would not, made it obligatory that the spans should be so hinged as to permit of this vertical motion of the piers without altering the strains in the truss. It was finally decided to construct the bridge with a central span, which may be described as a beam supported near each end, the overhanging portions helping to support the central portion, the piers acting as fulcrums.

The end spans were supported at the shore ends by abutments, and at the other end by the weight of the middle span acting over the piers as levers, the distance from the pier to the contraflexure point being the short arm of the lever. This important point was found by dealing with the truss, panel by panel, and member by member. The truss is 37½ feet deep, 18 feet wide, and each span divided into 20 panels of 18¾ feet each. All connections between the ties, posts and cords were made by pins. Those pins which were strained in erection were forced in place by hydraulic pressure and served as rivets, while other pins were put in loosely. The dimensions of piers and masonry, and the results of the final tests were given, all proving of very great interest.

THE PHILADELPHIA WATER SUPPLY.

MEETING, MAY 18TH.—Mr. Henry G. Morris made some very interesting remarks in regard to the proposition which Messrs. William Cramp & Son have made to the Philadelphia Water Department. They propose to furnish steam pumping machinery and foundations, boilers and air vessels complete, with all valves and attachments inside the house, to the pumping mains proposed to connect with the distributing pipes of the Belmont Water Works, on the east side of the Schuylkill river, and operate the same.

They also propose to furnish all coal, stoves and supplies, provide attendants, and maintain repairs free of all charges to the city for the first cost and operating expenses, for the same sum per million of gallons pumped as it now costs at the Belmont works, that being the lowest cost in the list for steam pumpage. At the expiration of five years from the time the machinery is started, it shall become the property of the city of Philadelphia without further cost or expense; ground and houses to be furnished by the city and located at the Schuylkill works, the department to so arrange its pipes that any excess of pumpage not required on the east side can flow into the Belmont basin, in order that continuous pumpage can be maintained. The machinery to be capable of pumping fourteen millions of gallons per twenty-four hours, the quantity of water pumped to be determined by the method now used by the department, and payments to be made quarterly on quantities certified by the Chief of the Department.

The cost at the Belmont works, the cheapest of any of the works in the city, for pumping 1,000,000 gallons 200 feet high was, in 1877, $14.12. The Messrs. Cramp have stated that they are satisfied that by using their own engines they can supply 14,000,000 gallons every twenty-four hours at the same rate as now done at the Belmont works ($14.12), and still make a good profit.

Mr. Morris gave an estimate of the cost at which the work could be done, and by comparison with the duty of the Lowell engines showed approximately what profits might be expected. At Lowell, Mass., the cost was, in 1877, $10.71 per million gallons for raising water into the reservoir, a height of 166 feet, with the Morris engine.

SEABOARD PIPE LINE.

MEETING, MAY 18TH.—Gen. Herman Haupt made very interesting remarks in regard to the Seaboard Pipe Line. About two years ago the Pennsylvania Transportation Company called upon General Haupt for estimates in regard to cost for transporting oil to the seaboard by means of pipes. The first pipes in the oil regions for the transportation of oil were laid fourteen or fifteen years ago. At present there are some 2,000 miles of pipe in operation between the wells and railroads.

At first the pipe line companies met with a very determined opposition from the teamsters and boatmen, but after waging a bitter war against the new system, they had to succumb, and pipe lines became the only mode for conveying oil from place to place. The Legislature passed an act allowing pipe lines in four or five of the western counties. The conduit was started to operate between the oil regions and Pittsburg. After a sharp contest with the Pennsylvania Railroad, it succeeded in getting across the line of the railroad by using a public road. The oil was received in tanks, which were

mounted on wheels, hauled across the railroad, pointed into receivers, and went on its way to Pittsburg. Even with this extra expense of handling the line paid well.

Upon visiting the oil regions it was found impossible to get satisfactory data for formulating the hydraulic pressure and making necessary calculations for an estimate of cost for a long line. The seaboard line propose to use a six inch pipe, which will give a capacity of 6000 barrels discharge per day; the line will be tested to 1,800 pounds pressure per square inch. Preliminary surveys have already been made. The first station will be located at Parker City, from which the oil will be forced a distance of thirty-five miles; the second pump will force it twenty-six miles further, the third pump seventy miles further, and the last pump, which shall be located on the west side of Tuscarora mountain, will send it to Baltimore, a distance of 102 miles. The pressure at each station will be 400 pounds, equal to a head of 1200 feet of oil. The distance between stations varies with the profile of the ground crossed.

The estimated cost of transportation is one cent per barrel at each pump, the distance between pumps being immaterial. Five cents per barrel is a full estimate of cost for transportation from the oil regions to the seaboard. A six-inch line of pipe can be made at a cost of $8000 per mile, making the total cost of the projected line $1,750,000. Construction of the seaboard line will be commenced in two or three weeks.

One of the most important points in the construction of pipe lines is to allow for contraction and expansion due to changes of temperature. A pipe line is certainly the most economical and natural method for transporting fluids.

WOOD-PRESERVING BY CREOSOTE (Hayford Process.)

MEETING, OCTOBER 19TH.—Mr. E. R. Andrews, of Boston, spoke on the subject of creosoting timber. Decay in wood is due primarily to the fermentation of the albumen of the sap, which commences as soon as the necessary conditions, heat and moisture, are provided. Fungus growth, thus developed, spreads rapidly until the woody fibre is completely disintegrated, its strength is lost, and by degrees it crumbles away. Hence the aim in wood preservation has always been to prevent fermentation by coagulating the albumen of the sap. This result is more or less effectually attained by the use of solutions of the metallic salts in the methods known as burnettizing (chloride of zinc), kyanizing (corrosive sublimate), boucherizing (sulphate of copper), etc. These salts are dissolved in water and introduced into timber either by pressure or by chemical action, the timber being subjected to a bath of same for a longer or shorter time.

These solutions act chemically upon the albumen, and for a time they do retard decomposition, but their effect is only partial; they will in time redissolve and be washed out by rain. Moreover, they do not at any time afford any protection to the fibre itself. If the timber be exposed to moisture, it will be absorbed as readily as by unprepared timber, and moisture will introduce among the fibres the seeds of decay, upon which the previously injected solutions of metallic salts will have no effect. Creosoting, however, does more than coagulate the albumen. This it does more effectually than either metallic salt, and it also forms a protection to the fibre. Creosote oil is insoluble in water. Hence, by this process, the pores are filled and the fibres are clothed with a substance which cannot be

washed out by rain. Time has no effect whatever upon it, and the fibre, protected from air and moisture, becomes "practically imperishable."

The preservation of timber by injecting creosote oil was first introduced by John Bethell in England, in 1837, and it has outlived all other processes. The use of the metallic salts is abandoned in Europe, except that railroad sleepers are treated in some parts of France and Germany with sulphate of copper, on account of the scarcity and high price of creosote oil.

The "Hayford" process differs from the "Bethell" mainly in this particular: the latter can only be applied to seasoned wood, while by the former green wood is preferred. You will readily understand that the more nearly the condition of timber is to that of a living tree (the sap and moisture being withdrawn from the pores), the more readily it will absorb oil. It is certain, that when timber has been seasoned in the air, the pores become more or less filled up, the fibres harden and contract, and the wood cannot absorb oil as readily as though the pores were open and nature's pumps for transmitting sap were in working order as in freshly hewn timber.

To withdraw the sap and moisture without hardening the fibres is then the first step in the Hayford process. This is effected by means of steam heat and air pressure. The wood is loaded on iron cars and run into a strong iron cylinder, which is then hermetically closed. (I will not attempt to give a lengthy description of the apparatus, which is exceedingly ingenious and very strong. It would consume too much time. You will, moreover, find it in an address which I made before the Franklin Institute of this city last winter, and was published in their journal for March and April, 1878.)

Steam is then passed through a long coil in the bottom of the cylinder and also, to a certain extent, free steam is admitted into the cylinder itself. But steam alone would not heat the wood sufficiently to vaporize the sap. The radiation from the broad surface of the cylinder and the condensation would prevent the temperature from rising above 150° to 180°. To secure a greater degree of heat, by means of a powerful air pump worked by steam, atmospheric air is pumped into the cylinder until the gauge shows a pressure of 30 or 40 lbs. to the square inch. Thus a double result is obtained, *i. e.*, a temperature of 240° to 250°, and also this pressure upon the surface of the wood tends to counteract the tendency of wood to crack in consequence of the expansion of the moisture within.

During this seasoning process, which often occupies several hours, if the timber be of large size, certain valves are kept open to allow the escape of the condensation and also to create a current of air, which of itself aids in the drying process.

Experience alone will determine when the wood has been subjected to the steaming process long enough to heat the wood to a point when the sap and water will vaporize. Then, by closing one set of valves and opening others, the air pump becomes a vacuum pump, with which the vapors are withdrawn from the cylinder and the wood. The wood parts with its moisture to such an extent that several hours' work of the pump are needed to produce a vacuum of 24 inches, whereas, without steaming the wood, the same vacuum would be reached in half an hour.

Thus, then, the sap and moisture have been withdrawn from the green wood without hardening the fibres; the wood is in a vacuum with its pores open and ready to drink in the oil, which is now admitted, having been previously heated to about 200° Fah't. The oil enters through perforated pipes, by which every stick is at once

bathed with oil, which is absorbed rapidly. When the cylinder is full, the contents are subjected to a pressure of 100 lbs. to the square inch, until the wood has absorbed the requisite quantity. This completes the process.

I stated above that "Creosoted wood is practically imperishable." This may appear a strong statement, but I think it is borne out by facts, when the operation of creosoting has been thoroughly performed. This process is too recent in this country to afford much demonstration. A few hundred creosoted ties were laid in the road-bed of the Philadelphia and Reading R. R. in 1875. These are in perfect condition. Ten thousand creosoted Virginia pine ties were laid in the Central R. R. of N. J. near Bound Brook before the Centennial. All the traffic of that road has passed over them in that time, and they have stood the test well. They have not cut in the least under the rail, and are in better condition than white oak ties laid in the same place at the same time. This experiment will be useful in showing the superiority of a cheap and comparatively valueless wood, creosoted, over the best kinds of timber untreated for R. R. ties. The former in many parts of the country will cost about the same as the latter, and taking European experience as a precedent, last at least twice as long and then be useful for sidings or fence posts.

In two numbers of the Chicago *Railway Review*, May 11th and 18th, 1878, is a translation which I made from the State records of Belgium of an article on the use of creosoted ties on the State railways of Belgium, by Charles Coisne, Superintendent of the creosoting establishments connected with the railways. This article will interest every engineer. It shows that during ten years 1,682,880 creosoted ties were laid, or about two-thirds of the whole number in use; and all of these, except 4400, were of fir. Mr. Coisne describes the condition of the creosoted ties exhibited at the Paris Exhibition of 1867, which had been in use from 16 to 21 years. He also describes an experiment of his own with 100 thoroughly creosoted ties, which lasted an average of 19 years.

An extended correspondence with the Chief Engineers of all the Railways in Great Britain the past summer discloses the fact that creosoted Baltic fir ties are alone used on all the roads in that country.

Several creosoted fir ties have been sent by these engineers, which have been in use from 12 to 20 years. One sent by Mr. Harrison, Chief Engineer of the North Eastern Railway, about which he says:

"New-Castle-on-Tyne, England, Aug. 2d, 1878.

"This sample of a Scotch fir sleeper, creosoted, was on July 29th taken promiscuously out of half a mile, that was laid down in our main line, near Tweedmouth, in June, 1858, thus having been in use for 20 years. I consider them still in a very good condition, and likely to wear other ten years yet; they have been run over during that time by all the passenger and goods trains between London and Edinburgh."

Half of this sleeper is in the Museum of the Am. Soc. of Civil Engineers in New York. It is perfectly sound. It is not cut in the least under the rail. There are only two spike holes to each rail, and the wood about the holes and under the chair is firm and solid. The wood itself is far harder than fir in its natural condition. It would be ranked among very hard woods. It shows the truth of a statement made at a meeting of the Institute of Civil Engineers in London some years ago, that creosoted wood is the only wood which improves with age.

Time will not allow me to do more than mention the other quality of creosote oil, which is of vast importance in this country, *i. e.* it

is the only substance which is known with certainty to be a protection to piles, etc., exposed in salt water to the teredo and marine insects. All timber used for dock purposes in Europe is previously creosoted; this use of creosoted timber is not new and experimental merely, but has been fully tested.[1]

I have just received from Capt. Truxton, Captain of the Navy Yard at Norfolk, Va., two blocks of white pine, one creosoted at my works and the other untreated. They were exposed in the water June 1st and taken out Nov. 1, 1878. The pine plank, to which the blocks were attached, and the untreated block are completely riddled by the teredo, while the creosoted block was not touched by that destructive mollusk.—

Mr. Andrews exhibited specimens of various kinds of wood very thorougly impregnated with creosote oil, and specimens of railway sleepers, which had been in use in Europe from 12 to 20 years, and were perfectly sound. He also showed blocks of wood, which had been partially creosoted and then exposed in the sea where the teredo is destructive. They were completely riddled except where protected by the creosote oil, and those portions had not been touched; and other specimens, which had been exposed in the sea in California and Aspinwall, where the holes cut by the teredo were $\frac{3}{4}$ of an inch in diameter.

BUTLER MINE FIRE CUT-OFF.

MEETING, OCT. 19TH.—Mr. I. W. Morris read a letter from Mr. C. F. Conrad, which gave the following interesting information:

"Before locating the line of the cut-off, I learned of the first fire which they had in the same vein (14 feet thick) in 1856-57, and after careful inquiry learned its position and made my location for the through cut to pass as near as possible through the centre of the 'old fire.' This was done, hoping to find all combustible matter, coal, 'gob' and carbonaceous slate burnt to ashes, in which case it would have saved many thousand yards of excavation, as it would have presented an impassible barrier to the progress of the present fire.

"This cut-off afforded an opportunity rarely, if ever, equaled to learn truly and fully the work of a fire in a coal mine. It was found the slate above and surrounding the coal and all the 'gob' was burned either to ashes or into slag, resembling ordinary furnace slag, while the pillars of solid coal were perfectly sound and bright. About the middle of the fourteen feet vein of coal is an eight inch line of slate, and this was found burned to a white ash, while the coal above and below were perfectly bright. When the fire reached the end of the workings it made no further progress, but, after burning the fallen rock to ashes or slag, it entered the face of the coal two or three inches and then went out."

Mr. Conrad concludes by saying that he is led to believe that solid coal cannot be burnt in place; that slate rock found in coal veins contains more gas than the coal; that fires in coal mines are fed and live on the "gob" (refuse slate, etc.) and gases, and that "gob" is an excellent reservoir for gas. Ventilation will carry off free gas, but "gob" holds gas as a sponge does water.

[1] See translation by speaker of a paper by Von Baumhauer, of Holland, in Pop. Science Monthly, Aug. and Sept., 1878.

THE ST. GOTHARD TUNNEL.

MEETING, DEC. 7TH.—Mr. Coleman Sellers, Jr., read extracts from a private letter written from Geneva, October 1, 1878, to a gentleman of this city, by Mr. Walton W. Evans, the eminent consulting engineer. . . . "I went over the St. Gothard Railway with the engineer, as far as the big tunnel, to see the most difficult railway works ever attempted in the world, nearly one-third of the whole line is in tunnels. In some places the railway is put in tunnels to get it out of the reach of avalanches; in one case the engineer pointed out to me, as we were riding on the highway, 60 to 70 feet above the river, the place where an avalanche came down last summer, filling the whole valley and coming up into the road where our carriage was. I will enclose to you a sketch of a piece of the location of this railway taken from their map. Their fixed maximum gradient is 1 in 40; their fixed minimum radius of curvature is 1000 metres. There are no side valleys to run up and back again to get distance, and as the valley in some places rises faster than the fixed gradient allows, the engineers are forced to tunnel into the sides of the mountains in entire circles (corkscrew circles) to get distance. The sketch I enclose shows three of these circular tunnels about eight kilos north of the big tunnel.

"The waved lines show water-courses, *G G*, being the river Reuss. The full lines show the location of the railway lines, and the dotted lines the tunnels. The points *A*, *B* and *C* show bridges over a cascade. The bridge at *B* is about 500 feet above the bridge at *A*, and the bridge at *C* is about 300 feet above that at *B*. The circles in the tunnels are 2000 metres, or 6502 feet diameter.

"On the south or the Italian side of the big tunnel, are more difficult locations still. The roads here are beautiful, built and kept in order by the State. All their work is well done.

"The tunnels of this railway (even the big tunnel is solid granite, and wide enough for three tracks) are arched with granite, but little inferior to the face work of the Astor House. You can imagine that none but the rich nations of Europe could, for a moment, think of building such a railway.

"I was run into the big tunnel for two kilos, on one of their air engines, to see a drilling machine I once explained to you. Baron Lauber tells me it is pressed against the rock with a pressure of 130 atmospheres, and that it walks into granite as if it were cheese."

* * * In regard to the abundance of water-power in Switzerland, Mr. Evans says: "There is a tremendous water-power going to waste all over Switzerland; you can see in hundreds of places streams of water coming down nearly perpendicular for 1000 or 2000 feet. At

the great tunnel of the St. Gothard Railway the river Reuss crosses the very mouth of the tunnel, and gives the engineers a water-power fifty times greater than they can use for compressing air, making repairs, etc., etc."

NOTE ON BRIDGE ERECTION—PITTSBURG AND LAKE ERIE R. R.

MEETING, DEC. 21ST.—Mr. D. McN. Stauffer communicated the following: One of the chief advantages of the American system of bridge construction is the speed with which large spans can be erected, over streams subject to sudden floods, etc., when time is of the utmost importance.

As furnishing another example of rapid construction, one surpassing by far, in time, anything before attempted or at least accomplished on the Ohio river, I have gathered some notes from Messrs. Cofrode & Saylor, the designers and erecters of the bridge in question. This bridge crosses the Ohio river at Rochester, Pa., on the line of the Pittsburg and Lake Erie R. R. It is 2500 ft. long, and the rail is 90 ft. above ordinary water level.

The main channel span is 442′ 9″ long from pier centres, (21 panels 21′ 1″ each), is 42′ 2″ high between pier centres, and 18 ft. wide between truss centres. It is a single track through span, made entirely of wrought iron, the only cast iron used being in a few small filling pieces. The design of the truss is a "double cancellation Pratt." It weighs 3500 lbs. per lineal foot, or has a total weight of 1,600,000 lbs. As before mentioned, the rail on this span is 90 ft. above ordinary water level.

The erection of this channel span, to which especial attention is called, was attended with great risks, from the sudden and frequent rise of the river and from the almost constant passage of heavy tows of coal barges from Pittsburg.

The false works consisted of three equal spans of wooden Howe truss, supported by two wooden trestle piers, which piers were in turn supported by piers of dry masonry about 10 ft. high, resting upon platforms sunk on the river bottom.

On Aug. 10th, 1878, the contractors commenced setting the false works, and though they were very considerably delayed by a freshet in the river, this portion of the work was finished on Aug. 24th, or in 14 days.

On Aug. 24th, they commenced packing the lower chords of this channel span, and on Sept. 7th they swung the span, in just two weeks' time, and just escaping a heavy rise in the river, and on Sept. 20th the first engine passed over the bridge.

From July 16th to Aug. 1st, or in in fifteen days' time, the same firm swung two 230 ft. deck spans and one 260 ft. through span.

The task of connecting and swinging a truss, weighing 1,600,000 lbs., at a height of 90 ft. or to the top chord of 130 ft. above the water, in so short a time, and over a treacherous river is one of which the builders may justly be proud. As I have before remarked, it has never been equaled over the Ohio river. With the English and Continental system of riveted lattice, a span of like dimensions would have consumed more months than these men took weeks, besides making necessary a most elaborate and expensive system of false works, to insure the safety of the work, through so long a period of time.

IRON CARS FOR RAILWAY SERVICE.

MEETING, DEC. 21st.—Howard Fry, Corresponding Member, communicated the following Notes on an Iron Box Car running over the Philadelphia and Erie Division of the Pennsylvania Railroad, in Empire Line service.

This car was built as an experiment by Murray, Dougal & Co., of Milton, Pa., and is of the ordinary dimensions and weight of a Penna. R. R. box car. The framing of the car is all iron except the end sills and the centre stringers which are of wood. The iron sills are plain I beams; the floor, sides, and roof are composed of thin iron plates and there is an inside lining of wood up to the load line of grain. The car has been running since March, 1878. In seven months from time of starting it ran 14,094 miles, principally between Philadelphia and Erie, though sometimes going west as far as Detroit and Chicago. Its lading was occasionally miscellaneous freight but principally grain in bulk, and the loads carried amounted to of wheat 30,000 lbs. and corn 29,000 lbs. At the end of seven months' service, the car was inspected and no sign of weakness could be noted. When loaded the body bolsters are held clear of the friction irons on the sides of the trucks so that the trucks are truly "centre bearing." The car is considered to have stood the wear and tear better than a wooden one, and no trouble was experienced by the grain heating during the past exceptionally hot summer, on which point many fears were entertained when the car first went into service.

No repairs have been made on the car up to date. The time will arise when the question as to the suitability of iron for car building will be an important one, so it may be useful to our members to know where *one* at least of such cars is being tried. I have not added any detailed dimensions as that is not an important point in the present stage of the question; if it is once decided that the *material* is suitable, its proper application will be more carefully studied than in the cars heretofore built. The designer of the car I have noted, would make considerable improvements if he were to build any more. The history of iron cars in America is a curious one; they have been used on some lines for 15 years and, if you were to ask why they are not more generally known, the people who have had most experience with them would be least able to show that they have been failures.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

IN MEMORIAM.

It is with sentiments of more than ordinary regret that we announce to the members of the "Engineers' Club of Philadelphia" the death of our late Vice President, Mr. J. B. KNIGHT.

Although Mr. KNIGHT'S connection with our organization has been brief, we cannot but realize that in his unexpected death we have lost an active and distinguished member, one who by his worth as a man had endeared himself to all with whom he came in contact, and by his recognized skill and long experience as an organizer and director had already done much to advance the best interests of our association.

Mr. KNIGHT was, perhaps, best known through his connection with the Franklin Institute of this city, and we are indebted to the proceedings of the Board of Managers of that institution for the data from which the following memoir is compiled:

JACOB BROWN KNIGHT was born near Brownsville, Jefferson county, N. Y., on June 2d, 1833. He was the son of George J. Knight and Abi Brown, his wife, and the grandnephew of Major-general Jacob Brown, commander in chief of the United States army, and a distinguished officer of the war of 1812.

His paternal ancestors, were members of the Society of Friends, and among the original settlers of Philadelphia—Giles and Mary Knight having been fellow passengers of William Penn in the ship *Welcome*—and landed first at New Castle, October 27th, 1682. They took up land in Byberry, Philadelphia county, Pa., where their descendants are yet numerous.

In 1804, Mr. Israel Knight, the grandfather of the subject of our memoir, bought a tract of land at Black River, in the State of New York, and upon this tract his son George settled with his family, and here Mr. J. B. KNIGHT was born.

He received his early education at the Watertown Institute, and

while still a youth evinced a decided taste for mechanical pursuits, which taste was developed by his training in the machine works of Hoard & Sons, Watertown, and in those of Merrick & Sons, in Philadelphia.

His health failing him, in 1855 he went South, and was there engaged in the erection of sugar and cotton machinery until the breaking out of the rebellion, which proved disastrous to his fortunes. He then became a consulting engineer in the city of New Orleans, was an officer of a society of engineers established there, and an occasional contributor to DeBow's Review.

Mr. KNIGHT, having returned to Philadelphia, was in 1873 made a member of the Franklin Institute, and on July 1st, 1874, he was appointed General Superintendent of the Franklin Institute Exhibition.

The marked success of this exhibition was, in a great measure due to the untiring zeal, the intelligence and executive ability of Mr. KNIGHT, coupled with his previous experience with an industrial fair held in the city of New Orleans.

The Franklin Institute in January, 1875, testified its appreciation of his services by electing him its Secretary, and he was annually re-elected, and most satisfactorily performed all the varied duties of this position until about ten days before his death, which occurred on March 10th, 1879.

At the time of his death, Mr. KNIGHT was Secretary of the Franklin Institute, editor of the *Journal* of the Institute, representative of the Institute in the Board of Trustees of the Pennsylvania Museum and School of Industrial Art, Vice-President of the Engineers' Club of Philadelphia, and member of the American Philosophical Society.

ANNUAL ADDRESS

OF PROF. LEWIS M. HAUPT, C. E., RETIRING PRESIDENT.

Read January 8th, 1879.

GENTLEMEN:—In closing this meeting, which is the last chapter in the first volume of our history, it is my privilege to call your attention to a few of the many valuable and interesting facts relating to the development of Engineering as a science, and to the progress that has been made in it during the past year. Originally it was an art or handicraft, but even at the earliest date of which we have any authentic record we find that mind, matter and motion were subject to the same laws as those existing at the present time. Some of these have only been developed after centuries of patient and laborious inquiry, whilst others yet remain enigmatical, awaiting the more systematic and concentrated combinations of future scientific inquiry.

* * * * * * * *

But the development has been exceedingly slow and laborious—for the attention of primitive man must have been directed to his physical wants, and to provide for them he was doubtless obliged to resort to manual labor, his first care being to apply such materials as were most available and appropriate to his immediate needs. As he acquired dexterity in his handicraft and discovered new materials, he was enabled to provide tools and utensils for facilitating his operations and increasing his comfort and convenience.

Abodes were felt to be indispensable, so we find the earliest authentic account of any construction is that mentioned in the fourth chapter of Genesis, where it is recorded that Cain builded a city and called it after the name of his son Enoch.

The next development mentioned is that Tubal Cain (six generations later) was "an instructor of every artificer in brass and iron." Thus the forge fires of that master blacksmith, glimmering on that ancient horizon, may be regarded as the symbol and origin of the grand mechanical outgrowth which has given power and stability to all the arts and sciences.

A few generations later, and we may discern Noah, the first marine architect, engaged upon his colossal Ark, built with such wonderful regard to the principles of the equilibrium of floating bodies, and the

requirements of the intricate problems connected with the storage and safety of his indiscriminate cargo and its subsistence for one year.

*   *   *   *   *   *   *   *

But we have not time to trace, even in outline, the history of these art developments, nor to specify the many excellent engineering works of the ancients. Suffice it to say that experience was found to be a good teacher, and through many failures mankind plodded on to success.

*   *   *   *   *   *   *   *

Yet it is an indisputable fact that there is, even at present, a lamentable need for more reliable data concerning the materials we are constantly using. The rules-of-thumb which have been laid down by practical men are inapplicable to the ever-varying conditions of the crude material, methods of manufacture, special uses, etc. These defects may be avoided by a more intimate knowledge of the strength of the particular material used and of its proper position in the structure. These properties should be determined by a competent Board of Inspectors, to whom may be submitted for testing all kinds and classes of materials used in construction. The tests of manufactured articles to be made under, as nearly as may be, the same conditions, and the results published in a bulletin to be issued by said Board at least weekly. The U. S. Board for Testing Iron and Steel was a move in the right direction, but the failure of the appropriation has brought its labors to an untimely end.

I would go farther, however, and co-ordinate, as far as practicable, *all* the branches of science, in a body of experts to form an INSTITUTE OF EXPERIMENTAL SCIENCE, composed of the highest grade of experimenters obtainable, who should be paid for their services and be expected to devote their entire attention to their several specialties, but holding frequent joint meetings for the reading of papers and discussion of methods and principles. The establishment of such an institution, properly equipped for experimentation in the many departments of science, would doubtless be an expensive undertaking, but the result would be a far more rapid and general diffusion of knowledge than when individnals grope about alone in search of new truths or combinations.

It must not be supposed that because discoveries and inventions are so frequent there is nothing left for the exercise of our faculties—for every additional element added to the sum of our knowledge only increases the possible number of new and useful combinations.

The information obtained through such an institute as is proposed would be useful in reducing the risks of traveling by land or sea, in diminishing the cost of transportation, and consequently the price of the necessaries of life, in increasing the safety of storage, the stability of construction, the rapidity of communication, the luxury and health of our homes by improved sanitation, light, heat and ventilation, and it might save the wreck of fortunes by preventing speculation in absurd or impracticable schemes, and be of inestimable benefit to the country generally.

To elaborate this scheme fully would consume far more time and attention than I can now give it, but I would earnestly suggest that it is one which, if it can be matured in the right spirit, will go far towards alleviating the condition of mankind, and add greatly to the general fund of scientific knowledge.

With reference to the inventions and discoveries of modern times, the developments have been made so rapidly that we can do no more than briefly recite some of the most important projects in the several departments of Engineering.

A moment's consideration will convince you that the chief duty of the engineer is to provide or increase the facility and safety of communication, whether by, through or on land, water or air. His work is inseparably connected with the construction of the road-bed and its rolling stock, whether it be the turnpike with its Conestoga wagon, the canal with its packets and barges, the railroad with its improved equipments, or the construction of pipe lines for the conveyance and distribution of fluids. But modern aspirations reach out beyond sixty miles an hour, and, like Puck, would put a girdle round the earth in forty minutes by the late evolutions of electrical science.

The telephone, phonograph, microphone, phonometer, and the subdivision of electric currents for illuminating purposes, are not new to you and need no description here.

These intensifiers of our human senses are but extending and opening the field of nature to deeper and more searching investigation, and are powerful auxiliaries in aiding us to discover the heretofore unknown causes of many phenomena connected with our existence.

The problem of Rapid Transit seems to have reached a satisfactory solution in the elegant accommodations furnished by the elevated railways of New York. The appointments have been wrought out with care, regardless of expense, and the returns and patronage exceed the

most sanguine anticipation. Even its most bitter opponents are obliged to concede that the system is a complete success. There is not so great need of a similar system in this city as its plan is capable of extension in all directions, and business is not so centrated. Still, there are some instances where an elevated road would be a great relief to our crowded streets. The track of the Pennsylvania and Philadelphia and Reading Companies, at least, should be elevated for the mutual benefit of those companies and the city. At the termini the cars could be readily lowered to the ground floor by elevators to receive and discharge cargoes.

For the transportation of fluids in bulk, it is a violence to the laws of nature and a drain upon the wealth of the community to seal them up in tanks, and move with every ton of such freight almost an equal weight of dead load, which must be returned to its starting point empty. It is a property of fluids to run down hill, and by an intelligent use of this property, with provision for the retention of the fluid in transit, its transportation becomes a matter of a few cents instead of ten or twenty times that amount.

Although these principles are so self-evident, and although thousands of miles of pipe lines have been in operation in the oil regions for many years, it was not until one of our honorary members, by a practical application of the principal of hydraulic gradients, demonstrated the feasibility of a line of over 300 miles in length, that the Seaboard Pipe Line Company (limited) undertook the novel task of constructing such a line of pipe for the transportation of petroleum. Contracts for the delivery of pipe have been closed, and the work is now being pushed rapidly to completion. The right of way has been secured by private purchase.

Another important modern improvement is the successful introduction of the Holly system of steam heating, which has been for several years and is now in use in Lockport, N. Y., where over three miles of pipes are laid. The steam generated by boilers is distributed by pipes laid about three feet under ground, and is used for heating, cooking, and, to a limited extent, for power, thus avoiding the great expense, inconvenience and danger of keeping up fires in each house for warmth or cooking. The power may be applied to operating light machinery, as lathes, sewing machines, jig-saws, etc., and will prove a boon to that overworked class of seamstresses who earn but a pittance a day at the cost of their lives. The system is spreading rapidly in other cities.

The mechanical difficulties of distributing heat as a fluid are no greater than in the case of gas or water.

In the field of mechanical Engineering the mind has not been inactive. Among the most beautiful inventions for the transmission of power through short distances, and in every conceivable direction, is the Stowe Flexible Shafting, which has been applied so successfully to many useful purposes.

Martin's true time regulator is also an ingenious piece of mechanism constructed to mark the apparent solar instead of the mean solar time.

The Pneumatic Tramway Engine Company of New York have perfected and successfully introduced machinery for using compressed air as a motor for street cars, at about one-half the present cost of horse-power.

The transportation and erection of Cleopatra's Needle has been one of the novel and interesting events of the year, which has also been marked by a large amount of work in progress on many vast engineering structures, as the East River Bridge, St. Gothard Tunnel, South Pass Improvement, and many other important works.

But this record of the march of improvement would not be complete without reminding you of the seal and stamp of commendation awarded to the skill and ingenuity assembled in the American Society of Civil Engineers by France, that critic of nations, especially on engineering subjects, in granting the highest Award of Honor to the above society for its excellent display at the late Exposition of '78.

We have now reviewed briefly some of the events of the past and present. It only remains to look into the future to discern some of the more prominent features of the work before us, and the relations which this club bears to that work.

If we desire to grow and be useful to the community in which we live, we must exert ourselves for its good, take an interest in its welfare, and lend a helping hand when required.

We should do all in our power to keep up the interest of the meetings, by communicating information, collecting materials for library, museum, etc., and bringing in desirable members. The Club should not hesitate to commit itself in support of any laudable measure tending to elevate the profession—as, for instance, the more general introduction of mechanical and free-hand drawing and the natural sciences into the public schools, in place of other less interesting and practical studies.

Another measure which I deem of great importance is that we should

make an effort as soon as possible to secure and retain in permanent form records of the early history of our American Engineering works. The best printed sources for such information are foreign, and our pioneers are rapidly passing away. Many of them have a fund of valuable and very interesting information stored up in their brains, which will be laid away with them unless some special effort be made to develop it; and I would respectfully suggest and urge upon you the propriety of calling a convention in this city, say in May or June, requesting each person invited to prepare a memoir of early experience, to be read at said meeting, when notes could be compared, corrections in dates made if necessary, and a great deal of valuable information obtained, which could never be collected in any other way. Such an occasion should be one of great interest to the members of the profession as a social event, and would not be without a good effect upon the Club.

An important field of labor is open in the direction of a check upon the wholesale destruction of timber and the preservation of its life by antiseptics.

Engineers should be urged, in framing contracts, to insist on the use of preserved timber whenever it is possible, both as an economical measure and a means of preventing the sudden climatic changes to which we are becoming so subject.

There is also a grand prospect open in the direction of sanitary Engineering. I cannot condemn too severely the present system of sewer construction. The lower half of the cylinder, being laid of dry bricks, simply serves as a seive to allow the fluids to soak through into the soil, leaving the solids to decompose in the sewers. The soil soon becomes surcharged with effete matter, and, as there are no traps or purifiers at the inlets, this fetid matter and gas is forced back by the rising tides into our streets and dwellings, causing epidemics almost as deadly as yellow fever.

The influence of temperature in destroying bacteria and spores, which propagate infectious diseases, is a subject well worthy of investigation. These are but a few of the many thoughts which might profitably engage our attention during the coming year.

In retiring from the place of honor to which you have so generously called me, I have to return my sincere thanks for the hearty co-operation and kindly sympathy you have ever extended towards me as your presiding officer, and to wish for you such measure of continued prosperity and usefulness as it may please an All-Wise Providence to grant unto you.

IX.

CONICAL ARCHES

At South Street Bridge, Philadelphia, Pa.

By D. McN. Stauffer, C. E.

The Eastern approach to South St. Bridge in this city is made up in part of a somewhat peculiar piece of arch-masonry, and as it contains certain novel features, that might be applied with advantage at other points, we will attempt to briefly describe it.

The centre lines of South St. and the bridge proper intersect each other at an angle of 33° 25′ necessitating a curve in the approach from the East, and to conform in design with the "late lamented" Western approach, this curve was pierced by three arches.

The ordinary practice in arches on a curve is simply to widen the pier ends towards the outside of the circle, and leave the arches themselves "right arches." But it was thought here that the work could be much improved in appearance and a considerable saving in masonry and foundations attained, by leaving the piers of the same thickness throughout, and throwing the eccentricity into the arches, and to this end the following plan was determined upon, after due deliberation and numerous experimental plans.

The foundations of all the masonry in the Eastern approach were upon hard gravel—timber platforms supporting the masonry—but as this gravel stratum communicated directly with the river, and was from 12 ft. to 15 ft. below high tide; the foundations were expensive, and any reduction possible in their extent was an item well worthy of consideration.

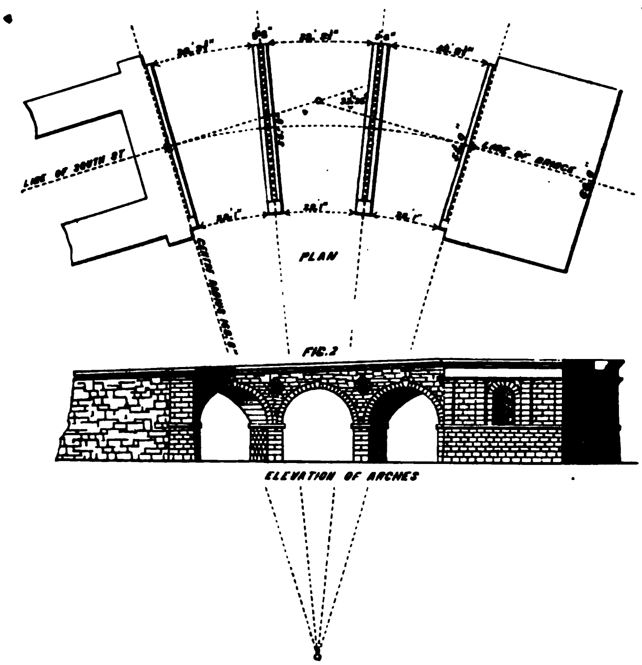
The roadway of the approach was 55 ft. wide from out to out, and the centre line of the curved portion, which curve was entirely occupied by the three arches, was located with a radius of 169 ft. 6 in, with an included angle at centre of 33° 25′. The abutments of the arches were consequently upon the tangents to the curve.

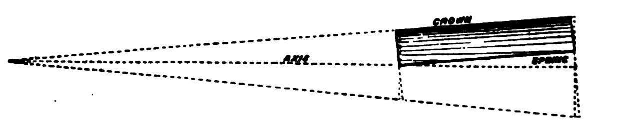
Each one of the two arch piers was 55 ft. long, 5 ft. 6 in. thick, throughout, and 12 ft. high from foundation to the springing line of the arch. The material used in these piers was Port Deposit granite, rock-face ashlar, cut in courses of from 17 in. to 27 in. rise, with "through headers" liberally distributed throughout the length of the

pier. The Skewback and coping, forming one piece was of Maine granite, hammer-dressed, and nearly every other section extended across the pier, making a double skewback, the sections averaging 4 ft. in width.

The centre line of each pier was located on a radial line of the

Fig. 1.

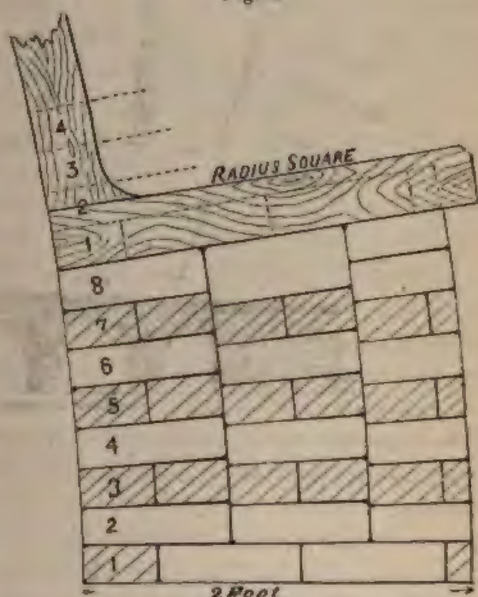




curve, the sides of the pier being parallel to this radius, and 2′, 9″ distant from it. The bounding radii of the curve fell in like manner 2′ 9″ inside the abutments, making the plan of the three arches equal, and in dimensions as follows: Each arch was 55 ft. long, the chord span at the inner end 22 ft. 1 in., and at the outer end 32′ 9⅜″. The rise of the arch was 11 ft. ½ in. throughout, the springing line and crown of the arch being both horizontal.

This arch is really a portion of a cone, and may perhaps be better described as follows: The line of the *crown* of the arch would fall in the "slant height" of the cone, and the plane of the *springing line*, would be a plane parallel to the slant height, and cutting the axis of the cone at the point which represents the face of the smaller end of the arch, thus making the rise at that smaller end equal to one half its chord span. The ends of the arch were cut at right angles to the slant height of the cone, and would be theoretically ellipses, but in this case the angle made with the axis of the cone was so nearly 90° that they were treated as circular arches. The fact that the springing lines were actually the flatter portions of a parabola — instead of straight lines—was in like manner, and for a like reason, disregarded.

Fig. 2.



The smaller arch was regarded as a full centred arch of 22′ 1″ span and 11′ 0½″ rise, and the other as a "segmental" arch of 32′ 9¾″ span, and 11′ 0½″ rise.

Maine granite was used for the ringstones and hard burned brick for the arch proper. The brick ring was 24 in. thick, and laid in cement mortar, formed of one portion Rosendale hydraulic cement and one part clean sharp river sand. The bond used in the brickwork can be better understood by an examination of the accompanying Fig. 2. The advantages of this bond were as follows: First and most important, by this arrangement, the thickening of the mortar joint as the extrados of the arch was approached was confined to the *length of one brick*, and this would be the case no matter how thick the ring, 2d. The arch was divided in its length into a series of true voussoirs, the bond repeating itself in each 8 courses. And 3d. The intrados of

the arch was uniform in appearance, the bond being a "header and stretcher bond" everywhere; in case of any settlement and consequent cracking of the arch, bricks arranged as these were could not fall out of the arch as readily as in a bond formed of a *series* of headers and a *series* of stretchers alternating, a common form of arch masonry.

The arch centres were built of 8″ × 8″ white pine timber and 2 in. plank, bolted together with 1 in. bolts; they were spaced 5 ft. apart from centres of ribs, and covered with a 2 in. planed lagging. The chord span of each rib, in the length of any one arch, was of course different from the rest, and to insure accuracy in this point, each rib was struck out upon a platform separately and framed on this platform. The ordinary "double wedge and key" was used in striking them.

One end of the conical arch being treated as a "full centre" arch, and the other as a "segmental" arch, the skewback joining them would be in theory a winding surface. But as economy of cash was the governing principle in this work, advantage was taken of the use of brick in the arch, and the skewback was made to approximate to theory by dropping the top of each section, say every four feet, one half inch below its neighbor, and cutting the face of the skewback to suit, cut without a "twist." In this way a series of slight steps was formed, passing from a radius of 2 ft., and a sine of 10 in. at the segmental end, to zero or a horizontal plane, three feet back of the full centre arch.

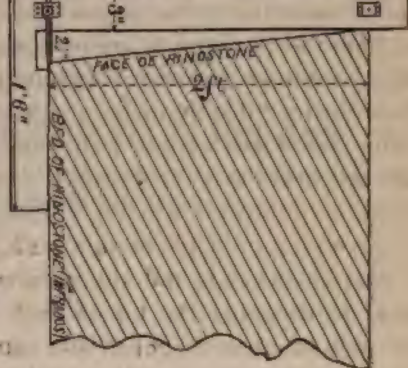
As the ringstones had all to be laid on lines radiating from the apex of the generating cone, the angle formed by the *face* of each ringstone and the *intrados* of the arch was one uniformly but constantly varying from the key to the springing line. The keystone was the only one in which this angle was just 90°. In the segmental arch the angle *increased* from 90° at the crown to 95° 20′ at the spring, and at the full centre end the angle *decreased* from 90° at the crown to 84° 40′ at the springing line. Each ringstone taken in the direction of its length was wedge-shaped, with its face wider or narrower than its back as it was located in the segmental or full center end of the arch.

As the curved portion of the approach was finished on top with a finely cut granite coping set on a regular curve, the ringstones had to be laid on the centres to fit this vertical curve, with its radii of 197 ft. and 142 ft. respectively. The versed sine, or the horizontal distance between the extreme point in the horizontal curve of the arch face at

the *crown*, and a chord line drawn at the *spring* of the arch, was at the segmental end 9 in., and at the other end 5 in. nearly.

All the granite work in these arches, except that used in the piers, was cut at the quarries in Maine, and to avoid the necessity of making and shipping a zinc pattern to conform to each face angle in the two sets of ringstones required, the following plan of giving these angles was devised. It was simple and worked well in practice.

Fig. 3.



An ordinary stone-cutter's square of iron was provided with a sliding graduated bar, and a set-screw as shown at Fig. 3. A separate bar with its proper graduations stamped and numbered upon it was provided for the two ends of the arch, there being 43 ringstones in the segmental arch and only 35 in the full centred arch. When used, the bar was placed at the *top* of the square when the face angle decreased from a right angle, and at the *bottom* when this angle was more than 90°. As each stone was cut it had a number and a letter painted upon, denoting its position in the arch, so that they were readily put in place. We should add that as the angles varied uniformly, a length on the bar equal to the tangent of the angle of greatest variation, from a perpendicular to the bed of the stone, with a radius of two feet, was divided into as many parts as there were ringstones between the springing line and the key. The ringstones were rock face with 1½″ draft, and the offset between any two adjoining ringstones was so slight that no attempt was made to conform to the winding face surface that theory required. The "pointing" was so managed as to hide the slight variation that did exist. The bed of the ringstone was first cut to a zinc pattern, then the build, and finally the face angle obtained with the square as above described.

The haunching of the arches was built of well-bedded lime stone from the Conshohocken quarries, laid dry, and thoroughly grouted, with one part Rosendale cement to two parts of sharp sand, at every

2½ ft. in height. The foundations were of the same stone, laid in cement mortar.

From the foregoing description it will be seen that strict theory was in all cases sacrificed, whenever it could be done without injury to the stability of the work, and much money was saved thereby. The final result was a piece of arched work that has stood perfectly in all its parts, and while possessing many advantages in appearance, really cost less than the more clumsy form, often adopted in similar cases.

X.

THE HOLLY SYSTEM OF STEAM HEATING.

Extracts from a paper by LEWIS M. HAUPT, Professor of Civil Engineering, University of Pennsylvania.

Read February 15th, 1879.

He who renders the necessities of life more available, either by reducing their price or increasing their quality, is a public benefactor.

The necessities of life are air, heat, light, food, raiment and shelter.

Of these six elements, it is my purpose to say a few words on the two essentials, air and heat, the invisible fluid components of every living organization.

Pure air is, beyond all doubt, the greatest blessing any people can enjoy, as it is the basis of health, strength and happiness; it is the fuel that feeds the animal combustion and keeps the machine in good running order, and without which the system becomes clogged and dead. Yet with our present modes of heating, it is almost a practical impossibility to obtain it in our dwellings in a condition even approximating to purity. In many instances it is drawn through foul, damp cellars, contaminated by the exhalations of decaying vegetable refuse, and, loaded with dust, ashes and noxious gases is sent into the rooms of our homes and offices, churches and halls, to be inhaled by all classes of society as the vital element upon which they must depend for existence.

It is an extravagant ignorance that closes its eyes to the deadly nature of the fuel which so rapidly smothers the flame of human existence, dulls the intellect and induces so many of the ills to which flesh is heir.

The poison is none the less sure or injurious because unseen; and so long as it is present, we have no alternative but to drink it. Our atten-

tion must be turned then to the best known methods of purifying it, or in other words, to the improvement of the methods of ventilating and heating our places of abode.

Chemists, architects and engineers have alike given the subject much careful consideration, and modern devices have been resorted to, even at great expense, to meet the requirements of the problem. Open fires have given place to stoves, these again to heaters, and these, in part, to steam coils, and yet the solution is unsatisfactory. A fire in each room is troublesome and dangerous; the hot air method is injurious and expensive, and the present system of steam heating dry and noisy.

To remove these objections so far as possible, one of our most distinguished and successful inventors, Mr. Birdsell Holly, has devoted the past few years to a patient analysis of the problem of heating by steam, and by an application of his fertile ingenuity, has conceived and introduced a system which is found to be not only exceedingly practical but general in its application to cities or towns of any class, and far more economical and much safer than any of the methods now in use.

The general plan of the plant is similar in principle to that used for the distribution of other fluids, as gas and water; that is, there are large generators, where the steam is made under a pressure of about 60 pounds. From thence it is conveyed to the buildings to be warmed by mains, buried about three feet, and connected with the service pipes leading into the houses, where meters are placed to register the amount of steam used. It can be turned on or off at pleasure and only used where and when required.

To render the air moist, and to dispense with the disagreeable noise, sometimes caused by closed pipes, Mr. Holly has introduced a new radiator, which is open at the bottom, so that the steam floats in the top of the box and is kept in equilibrium with the atmospheric pressure by a valve at the meter, so adjusted as to reduce the pressure in the house, if need be, to only a few pounds per square inch.

It evidently results from this arrangement that the air used for ventilation may be obtained from the purest available sources, and be heated in the compartment where it is used, instead of being drawn up through the cellar. No vapor escapes in the room, nor is there any difficulty in keeping the temperature at any desired degree. It is free from dust and avoids all risk of fires.

Above all, the economy of living in so delightful an atmosphere should recommend it to every citizen having the slightest regard for his health or his wealth.

I am well aware that conservatism is often a bar to progress, and that inventors have too frequently spent their lives and fortunes in vain efforts to convince their fellow men of the practicability of their schemes, but fortunately the experience of the past has paved the way for the rapid introduction of a system of distribution so closely allied to that of gas and water, and not open to such serious objections, as obtained in those cases. More than this, the plan has had a thorough practical test, and is approved and endorsed by a large number of people in the city of its birth, and its success is assured by its rapid adoption by a number of other cities throughout the north, where the severe winters have tested its capacities to the fullest extent.

The announcement of the "HOLLY STEAM COMBINATION CO. for supplying heat to private dwellings and public buildings of every description, from a central point, through street mains and laterals, and measure the steam used to each consumer," says:

"To quite an extent steam is already used in heating buildings. But the boiler and fixtures for single dwellings are very expensive, as is also the maintenance.

"In January, 1877, the Holly Steam Combination Company, of Lockport, N. Y., was formed under the statute, with necessary capital, to test the plans of Mr. Holly on a large scale. Three miles of underground pipe were laid, but little of it larger than four inches diameter, and after a series of exact tests and detailed practical experiments, and after the experience of a variable and peculiarly trying winter, the system is pronounced by all to be a practical and perfect success.

"The Company has through the winter been heating about forty large dwellings, scattered along the line, also a large school building, 105,000 cubic feet, and the largest hall in the city, besides furnishing steam to run two engines, one of them nearly half a mile distant from the boiler house, and are supplying steam for a number of other purposes.

"Houses a mile away are heated as readily as those near at hand. Three boilers are in position, two of them horizontal, 5 by 16 feet, and one upright. In the coldest weather two were fired slowly, but much of the time the steam has been furnished by a single boiler. The fire is, of course, kept up constantly. * * * Careful experiments demonstrate the fact that, with sufficient boiler capacity and pipes of proper size, an area of more than four miles square in any city or village can be warmed from one set of boilers. * * *

"The pipe is covered with non-conducting materials, and then inserted in logs of wood bored for the purpose." * *

The steam thus generally distributed may be applied successfully to a large number of operations, as the extinction of fires, cooking of food, heating water, running light machinery, laundry purposes, etc.

The mayor of Lockport. Mr. H. D. McNeil, under date of March 23d, 1878, says that the Holly Company have, for months past, been heating many private dwellings with perfect satisfaction; also one of the largest school buildings, which the members of the Board of Education state is better heated than any other of the public buildings. Taken as whole, he considers the invention one of the most valuable of the age, etc.

Many more communications of a similar nature have been received by the Company bearing testimony to the value of this improvement, which adds so greatly to the comfort and economy of living.

MINUTES OF MEETINGS.

Of the Club.

Jan. 11th, 1879.—The First Annual Meeting of the Club was held at 8 P. M., 15 members present, Prest. Haupt in the chair. The Annual Report of the Secretary and Treasurer was read and approved. Reports were likewise submitted from the Committees upon the Metric System, on Publication, and on Memorializing the Legislature in favor of a Geodetic Survey of the State of Pennsylvania. The President of the Club, Prof. L. M. Haupt, delivered the Annual Address.

The vote for officers for the year 1879 was then canvassed, and the following declared elected: Thos. C. Clark, President; J. B. Knight, Vice President; Wm. G. Neilson, Rudolph Hering, D. McN. Stauffer, Coleman Sellers, Jr., Percival Roberts, Jr., Directors; Herman Hoopes, Recording Secretary; Chas. E. Billin, Corresponding Secretary and Treasurer.

Jan. 18th, 1879.—A special meeting was held at 7.30 P M., Vice President Knight in the chair, 21 members present. Twenty gentlemen were elected active members of the Club, their election having been deferred until the adoption of the new Constitution and By-Laws.

At 8.30 P. M. the regular meeting was called to order. A paper upon "Conical Arches" was read by Mr. Stauffer, and briefly discussed by Messrs. Knight and Hering. Mr. Ashburner exhibited to the Club engravings of the Cleveland Viaduct, and a detailed statement of its

cost. An improved disk calculator for obtaining by inspection the quantities in earth-works, etc., and to assist in the calculations in surveying generally, was exhibited and explained by the inventor, Mr. Ross. Mr. Hering presented for the inspection of the Club an automatic stop-action applied to the Marquois scale, for dividing and cross-section-lining.

FEB. 1st, 1879.—Regular meeting held at 8 P M., Mr. Ingham in the chair, 26 members present. Mr. Ashburner read a manuscript report of Mr. D'Invilliers, Eng., in charge of surveys on the *Madeira and Mamore Railroad*, in Brazil, a report made to the Messrs. Collins, the American contractors. The report was accompanied by maps and profiles. Mr. Young read a paper upon "*The New River Coal Fields*," on the line of the Chesapeake and Ohio Railroad, which paper was discussed by Messrs. Harden and Marks. Prof. Marks exhibited and explained a substitute for a beam compass of his own design, being a negative form of "Peaucellier's cell," adapted to describing arcs with radii of from three inches to infinity.

FEB. 15th, 1879. A regular meeting was held at 8.30 P. M., Vice President Knight in the chair, 24 members present. Mr. Burnham read a paper, entitled "Some Features of Ancient Engineering," discussed by Messrs. Harden, Marks and Stauffer. Mr. Darrach exhibited and explained a set of diagrams, graphically showing the working of the Philadelphia Water Department for the past twenty years. Prof. Haupt read extracts from a paper upon the "Holly Steam Heating Apparatus."

On motion the following resolutions were adopted and ordered to be forwarded to Washington:

WHEREAS, A bill is now pending in Congress "For the Improvement of the Missisippi River," which bill provides for a commission under whose charge this work shall be prosecuted, which will contain no professional engineers except members of the Corps of Engineers of the U. S. Army.

AND, WHEREAS, It is the effect of this bill to exclude from the direction of an important public work all engineers not enrolled in the Engineer Corps of the U. S. Army, be it

Resolved, That the "Engineers' Club of Philadelphia" enter a vigorous protest against the specification above mentioned, and respectfully request that the bill may be so amended as to include in the Commission a representation from the *civil* branch of the engineering profession, containing, as it does, many men of eminence and long tried engineering experience, to whom in no small part is due the inception and successful execution of many of our most important public works.

MARCH 1st, 1879.—A business meeting of the Club was called at 8.30 P. M., Mr. Hering in the chair, 26 members present. Reports from Mr. Roberts of Committee on Finance, Mr. Stauffer of Committee on Membership, and Mr. Stauffer of the Publication Committe, were received and adopted.

The vote on admission to membership was canvassed, and the following declared elected active members: H. C. Francis, Arthur W. Sheafer, Percival Roberts, Alex. P. Gest, Gen. Wm. F. Reynolds, Chas. F. Moore, O. McClellan, M. F. Bonzano.

The resignation of Mr. J. S. Bancroft was read and accepted.

Prof. Haupt read selections from a report upon "the use of compressed air as a motor for street cars."

March 15th, 1879.—Mr. Howard Murphy acting as President; 25 members present.

Mr. Buzby read a paper on the "Travis Railroad Tie."

Mr. Colton exhibited a plan of the contemplated water works for the Middle Penitentiary at Huntingdon, Pa.

Mr. A. R. Roberts described a model of the Ainsworth Railway Switch.

Mr. Cooper described to the Club the Sand-blast Process of Sharpening Files, invented by Miles A. Richardson, and exhibited specimens of the work done.

Mr. Percival Roberts, Jr., made some remarks upon the death of Mr. J. B. Knight, and offered the following resolutions, which were adopted:

Resolved, That the Engineers' Club of Philadelphia express their grief at the loss of their fellow-member, the Vice President of the Club, Mr. J. B. Knight, who died after a short illness on Monday, March 10th, aged forty-five years. The services of Mr. Knight were of great value to the organization, and aided largely in bringing it to its present position. While, however, his loss is a severe one to the Club as a body, it is by the individual members that the severity of the blow is especially felt. Mr. Knight possessed the confidence and commanded the respect of the members in a high degree, and was to many a personal friend.

Resolved, That this Club sympathize deeply with his bereaved relations, and that these resolutions be spread upon the minutes.

The following contributions to the Library are reported:

From Rudolph Hering, member:

U. S. Coast Survey Reports, 1851 to 1868. 18 vols.

Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. 9 vols.

Owen's Geological Survey of Wisconsin, Iowa and Minnesota. 6 vols.

From W. A. Ingham, member:

Second Geological Survey of Pennsylvania. 6 vols.

From Claxton, Remsen & Haffelfinger, Publishers:

The System of Calculating Diameter, Circumference, Area and Squaring the Circle. By James Morton. 1 vol.

Slide Valve Gear. By Hugo Bilgram, C. E. 1 vol.

From T. Elwood Zell, Davis & Co., Publishers:
Zell's Imperial Library Atlas of the World. No. 1.

From American Philosophical Society:
Proceedings and List of Members. 5 vols.

From the author, William Kent, M. E.:
Strength of Materials.

From Institution of Civil Engineers, London:
Minutes of Proceedings. 2 vols.

From Minister of Public Works, Ottawa, Canada:
Annual Report, for fiscal year 1877–78. 1 vol.

Of the Board of Direction.

JAN. 18th, 1879.—A stated meeting was held at 12 noon. Estimates for the publication of the proceedings were examined, and an appropriation made for that purpose. Proposals for admission to the Society were considered.

JAN. 15th, 1879.—A stated meeting was held at 7.30 P. M. The matter of publication of proceedings was further discussed. Mr. Billin having tendered his resignation as Corresponding Secretary and Treasurer, owing to his temporary absence in Europe, it was read but not accepted, and Mr. Norris was appointed Corresponding Secretary pro tem, and Mr. Hoopes Treasurer *pro tem.*

Proposals for membership were considered, and other routine business transacted.

REPORTS OF COMMITTEES, ETC.

I. Annual Report of the Secretary and Treasurer.

For the year ending January 11th, 1879.

Mr. President and Gentlemen:

The present meeting closes our first fiscal year. The experiment of maintaining an Engineers' Club in Philadelphia has proved most successful, and we may all feel encouraged to go on in the good work.

Since its organization the Club has held eighteen regular meetings, including the present one. Considering its limited membership, the attendance has always been very large. The members, generally, seem to taken a great interest in the welfare of the Club, and have done much toward making it permanent and successful.

Our membership has been increased by the addition of forty-one names, to those of the organizers, making a total of sixty members of all classes. Three members have resigned, one name has been changed from the list of active to that of corresponding members, and we have lost one member by death.

During the year, seventy-nine bound volumes, between three hundred and four hundred pamphlets, besides a number of maps, drawings, etc., have been given to the Club. These donations have been received principally from the following sources:

American Society of Civil Engineers.
American Institute of Mining Engineers.
Franklin Institute of Philadelphia.
Brigadier-General A. A. Humphreys.
Hon. Secretary of the Interior.
Hon. Secretary of the Treasury.
Hon. Secretary of War.
United States Light House Board.
United States Coast Survey.
Smithsonian Institution.
United States Life Saving Service.
United States Department of Agriculture.
Major J. W. Powell.
Dr. F. V. Hayden.
Captain M. R. Brown.
G. Bouscaren.
Henry Gannett.
Sandford Fleming.
Pennsylvania Geological Survey.
Philadelphia Water Department.
American Iron and Steel Association.
Commissioners of Fairmount Park.
Hon. John F. Hartranft.
Hon. Carrol D. Wright.
Prof. George H. Cook.
Horatio Seymour, Jr.
Prof. Robert H. Thurston.
Henry G. Morris.
M. N. Forney.
Hon. J. Simpson Africa.
Professor Lewis M. Haupt.
Philadelphia Social Science Association.
Charles E. Billin.
R. H. Lee.
Charles P. Chouteau.
Edward R. Andrews.

The publishers of the following periodicals: American Manufac-

turer and Iron World, Iron Age, Metal Worker, Van Nostrand's Eclectic Engineering Magazine, Journal of the Franklin Institute, Bulletin American Iron and Steel Association, Engineering News, Railroad Gazette, Polytechnic Review, Scientific American, have, very kindly, been sending current numbers of their publications to the rooms of the Club.

Nothing has contributed more largely to the success of the Club, and toward keeping up an interest in the meetings, than the work of the several Committees on Information. Such a committee has reported at each meeting. Besides original papers written by members of the committees, they have also brought forward notes and suggestions upon various engineering topics, which have led to animated and interesting discussions. The principal subjects thus brought before the Club have been: Street Car Motors; Metric System of Weights and Measures; South Street Bridge; Mississippi Jetties; Phonograph and Telephone; Steam Boilers and Engines for High Pressures; Electrical Earth Currents; Raritan River Bridge; Occurrence of Coal in the Mesozoic Sandstone of Montgomery County; Seaboard Pipe Line; Water Supply of Philadelphia; Hayford's Process for Creosoting Timber; St. Gothard Tunnel; "Hay" Steel Process; Notes on Bridge Erection, Pittsburg and Lake Erie Railroad; Ainsworth's Automatic Switch; Notes on Iron Cars for Railroads; Adams' Pump.

The following papers have been read and discussed before the Club:

No. 1. Street Car Motors, by J. F. Robinson. (Not published.)

No. 2. Oil Sands of Pennsylvania, by Charles A. Ashburner. (Published in Journal of the Franklin Institute.)

No. 3. Lowe Gas Process, by George H. Christian. (Not published.)

No. 4. Drainage and Sewerage of Philadelphia, by Rudolph Hering. (Published in Van Nostrand's, Iron Age, Report of Board of Health, etc.)

No. 5. Bearing Piles, by R. Hering. (Published in Engineering News.)

No. 6. Proposed Removal of Smith's Island, by Prof. L. M. Haupt. (Published in Van Nostrand's Eclectic Engineering Magazine.)

No. 7. Water Supply to a Stamp Mill in Venezuela, with Notes on Kutter's Formulæ, by William F. Biddle. (Published in Van Nostrand's Magazine.)

No. 8. Empirical Formula for Estimating the Strength of Wrought Iron Beams, by P. Roberts, Jr. (Published in Iron Age.)

No. 9. Kentucky River Bridge, by Wm. F. Sellers. (Not published.)

No. 10. Want of Uniformity in Arranging Scales of Maps, with table, by Prof. L. M. Haupt. (Published in Journal of Franklin Institute.)

No. 11. Strength of Wrought Iron in Structures, by P. Roberts, Jr. (Published in Iron Age.)

A résume of the proceedings at each meeting has been published in the Philadelphia *Public Ledger*, and in most of the engineering periodicals of the country.

At the meeting held March 16th, 1878, a committee was appointed to report upon the advisability of adopting the Metric System of weights and measures as a standard. Their report was presented April 6th, and ordered to be printed. It has been widely published, and has received careful attention from many persons who are interested in the adoption of this system of weights and measures.

The Secretary prepared a Memorial to the Honorable Members of the Legislature of Pennsylvania, praying for a thorough geodetic survey of the State, and the accurate and permanent location of all county and township lines, which was read at the meeting held October 5th and ordered to be printed. Copies of the Memorial have been sent to all members of the Legislature, and to many persons throughout the State who would be interested and influential in the advancement of its object. It has received the signatures and hearty endorsement of many of the most prominent men in the State, and is at present under consideration in a committee of the House.

In June last, the Board of Direction of the American Society of Civil Engineers extended to members of the Club a very kind invitation to attend the Tenth Annual Convention of that Society, which was held in Boston, June 18th, 19th, 20th and 21st. Twenty-four members availed themselves of the opportunity to enjoy the privileges and benefits of that occasion, and I know there was not a man among them who did not leave Boston, after that most delightful week, with feelings of deep gratitude to the American Society of Civil Engineers, and to the Boston Society of Civil Engineers for their many kind attentions.

The first year of the Club's existence has certainly been a very successful one. The problem now is how can we increase its usefulness and value to members and to the public? It is evident that the membership of the club must be largely increased, and the amount of increase must depend upon the individual efforts of the present members. Judging from the number of applications for membership now under consideration, and the very favorable opinion of the Club entertained by most of the engineers resident in Philadelphia and its suburbs, we ought not to find any difficulty in adding at least a hundred members to our number during the next twelve months.

An offer has recently been made to rent to the Club larger and more convenient rooms than we now occupy. It is important that we make the Club room in every way attractive and comfortable, and this could probably be more easily accomplished in other than the present rooms. I would suggest that a committee be appointed to consider the advisability of making a change of quarters.

Nothing, however, is of more importance for the welfare and prosperity of the Club than that we should made some definite arrange-

ment with regard to the publication of transactions and proceedings. There seems to be but two plans, which are in every way practicable, for accomplishing this end. One is that we make a contract with one of the engineering periodicals for the use of a portion of its pages; the other plan is that we issue our own publications in pamphlet form.

Only one of the engineering periodicals has made an offer, and the arrangement which could be made with it would possess very few advantages and many disadvantages. This plan has, therefore, been given but little consideration.

The plan suggested, of issuing all publications from the Club in pamphlet form, possesses many and very decided advantages. The cost would be comparatively small, while the publications would give to the Club the notoriety which it deserves, and we would receive many valuable additions to our library in exchange for copies of the transactions. The publication of transactions would do much toward keeping alive the interest of each member in the affairs of the Club. Besides providing for the publication of papers read before the Club, and of notes and information sent in by members, each number of the transactions might contain notices of new and important books or pamphlets treating of engineering subjects, and much other information which would be of use and interest to the members.

During the year three assessments have been made upon the members of the Club; one in February, to meet the expense of a reception given to the American Institute of Mining Engineers, at the Penn Club; and two regular assessments (April 6th and Nov. 2d) for the ordinary Club expenses.

The following statement shows the amounts of receipts and expenditures for the year:

Received from Initiation Fees,	$ 71 00	
" " Assessments,	311 70	
		$382 70
By Reception to Am. Inst. of M. E.,	$ 86 70	
" Postage,	44 51	
" Printing,	30 77	
" Rent, to Jan. 1st,	56 25	
" Janitress, "	18 00	
" Gas Fixtures,	8 30	
" Fuel,	9 50	
" Fire Grate,	5 00	
" Engrossing,	7 50	
" Stationery, Notices, etc.,	92 72	
		$359 25
Balance on hand,		$ 23 05

Some of the expenses above enumerated may be classed as extraordinary, being such as we will not be called upon to meet again. It will be seen, however, that the revenue derived from dues is, with the present limited membership, just about enough to meet the ordinary

expenses of the Club. I have prepared an estimate of the receipts and expenses for next year, which I submit herewith.

In closing this report, allow me to express the sincere hope that each member of the Club will do all he possibly can to promote its every interest, and to establish it upon such a sound basis that it may be felt as a strong power, for the "advancement of engineering in its several branches" throughout this City and State.

Very respectfully,

CHAS. E. BILLIN,
Secretary and Treasurer.

ENGINEERS' CLUB OF PHILADELPHIA,
January 11th, 1879.

The Committee on the Metric System respectfully beg leave to report:

Since the last report, rendered April 6th, 1878, the committee have had published 500 copies of their report, which was unanimously adopted by the Club.

Copies of the report were mailed to the leading American scientific and engineering journals, to the principal scientific societies, public institutions and authorities. The report was republished in full in the *Journal of the Franklin Institute*, and was favorably noticed in *Van Nostrand's Engineers' Magazine*, *Engineering News*, *Engineering and Mining Journal*, etc., etc. Numerous acknowledgments were received from individuals, and the Committee have every reason to believe that the report accomplished the object for which it was published.

Respectfully submitted by the Committee.

CHAS. A. ASHBURNER, *Chairman.*

NOTES AND COMMUNICATIONS.

COST OF THE CLEVELAND VIADUCT.

The following table, compiled from the City Auditor's books, shows the expenditures on account of the Viaduct, in full, to Dec. 21st, 1878:

Costs of Court,	$1,523 77
Legal services,	1,000 00
Taxes,	443 59
Total amount paid for land,	522,880 23
Costs of superintending construction,	11,346 66
Miscellaneous expenses,	11,463 98
Engineers' Department pay-roll,	3,140 40

CONTRACTORS' ACCOUNTS.

Amount paid E. W. Ensign, of Buffalo, for west side masonry, river piers and grading,	1,240,348 11
Amount paid Louderbach & Co., of Pittsburg, for iron hand-railing,	8,071 20
Amount paid Sherman & Flagler, of Utica, N. Y., for masonry on east side of river,	25,744 26
Amount paid Claflen & Sheldon for iron spans and draw-bridge,	119,180 41
Amount paid Albion Medina Stone Company,	31,220 16
Amount paid John Mahon, Jr., for sewers,	2,278 14
Amount paid W. H. Thompson for steam engine and machinery for turning the draw,	3,690 00
Amount paid Maxwell, McBride and Malone for flagging sidewalks,	2,626 12
Amount paid Woodhull & O'Gorman for iron stairs west side of river,	1,419 30
Amount paid People's Gas Company for service pipe,	291 94
Total expenditures to Dec. 21st, 1878,	$1,986,668 13

The estimated cost made by the City Civil Engineer Dec. 28th, 1875, including the right of way and all the expenses, was $2,200,000. The total cost completed, it is estimated now, will be about $2,160,000. The cost of the structure alone will aggregate about $1,600,000.

The above table was sent me from a reliable party.

Respectfully submitted. CHAS. A. ASHBURNER.

Engineers' Club of Philadelphia, Jan. 18th, 1879.

REGULAR MEETING, FEB. 1st.—Through the kindness of Messrs. P. and T. Collins, contractors of the Madeira and Mamore Railway, Brazil, I am permitted to present to the Engineers' Club of Philadelphia an abstract of the report of progress made by C. S. D'Invilliers, Chief Engineer, together with tracings of the maps and profiles of the preliminary and located lines.

Respectfully submitted,

CHAS. A. ASHBURNER.

"SAN ANTONIO, October 10th, 1878.

"MESSRS. T. AND P. COLLINS:

"*Gentlemen*:—According to your request, that I should as soon as possible submit a record of our work and a report of the country we have surveyed, I have had plans made of all our surveys up to date, which comprise the country between San Antonio and Calderão do Infierno . . . . which I respectfully submit in connection with this report.

"Our examinations during the first two or three months, confined principally to the territory between here and Macacos, a distance of five miles by river, developed a country much broken by deep ravines, at the heads of which we found a plateau or ridge dividing the waters of the Jamari from those of the Madeira, which at different elevations continues to exist as far as the Jaci Parana River. The ground along the river's edge is flat and good, and with a low embankment would be available for railroad purposes, except from the fact that abrupt hills come flush to the river's edge at Macacos, Theotonio Falls and other points.

"Between the river and the dividing ridge there is no alternative . . . . but to climb to the plateau at a maximum elevation of 200 feet above high water.

"From San Antonio to the end of the sixth mile there is generally rough and comparatively heavy work; from there to the end of the forty-third mile, or six miles this side of the Jaci Parana River, the country is flat and gently rolling, at an average elevation of 400 feet above high water, over which a very cheap and generally favorable line can be obtained. . . . . . .

"Between the ridge and the Madeira River are numerous detached hills, many of them quite high, into which we ran with some of our trial lines. These hills are generally in the neighborhood of the rapids. . . . . Calling high water 200, the maximum elevation of the ridge is 400 feet, that of the detached hills 500 feet. . . . .

"Our survey along the Jaci Parana River shows us a very crooked stream from 350 to 400 feet wide during low water, with generally low banks from 2 to 8 feet below high water, and in some places high bluffs on one side and lower ground on the other. The highest and best ground on the west side is that which we have chosen for the crossing; it is about 8 miles from the mouth of the river by the river, and four miles in a direct line.

" . . . . From the crossing toward Santonio the ground rises gradually about 2 to 3 feet per hundred, until it reaches the plateau, which is 100 feet above high water, being level in a direction up and down the Taci Parana.

" . . . . Regarding water ways . . . . between San Antonio and Calderão, we shall require nothing in the bridge line except over a creek one-half mile from San Antonio and the Jaci Parana River. The creek is 150 feet wide at high water. Over the river from 350 to 400 feet of bridging will be ample. The necessary culverts will average one in every two miles. As for timber . . . . we can get tie timber anywhere. The timber is the heaviest on the first twenty miles, and gets gradually lighter as we approach the Jaci Parana River. Adjacent to the river small palms mostly abound, few of the trees being more than 10 inches through. . . . . The brush is everywhere very dense, making it impossible to investigate the country on either side of the line without running cut lines and levels. . . . .

"We have been much thrown back on account of sickness among the corps, resulting not so much from the unhealthiness of the climate as from the difficulty of keeping up the supplies of proper food. . . . . My own experience has been, that beyond a slight bilious tendency, the climate is not unhealthy, except perhaps through the months of July and August.

"There has been no suffering from the heat by those in the woods, although the temperature ranges at about 100° Fah. (max.) in the shade, and 120° (max.) in the sun. As to the geological features, I am inclined to think we shall find no solid rock except at stations 110 and 200. In nearly every cut in the first six miles we have found a decomposed granite cemented with clay or iron—in many cases granite boulders. That composing the Cachuelas is undoubtedly of volcanic origin.

"Regarding the location of our line to the Madeira River, after passing Macaco's, where we are 2006 feet in the closest point is at the sixteenth mile post, or two miles above Rosstown, where we are about two miles in. At Theotonio Falls, ten miles from here, we are six miles in; at San Carlos, twenty miles from here, three miles in; at the thirty-first mile post we are most distant, being nine miles inland; at Jaci Parana River four miles, at Calderão two and one-half miles, at Tres Irmãos we shall probably be on the river bank.

. . . .

I am, gentlemen, your obedient servant,

C. S. D'Invilliers, *C. E.*"

"November 25, 1879.

"Messrs. P. and T. Collins:

"*Gentlemen*:—I send you this month . . . . maps of the located line of railway from San Antonio to station 1100, or about twenty-one and one-half miles, and projected location from station 1100 to Calderão do Infierno or station 3530. The locating party are now about station 1700, and making very rapid progress.

"At the time of writing the track is laid to station 208, or four miles, and the grading from there to the end of the six miles of heavy work more than half finished. Considerable of the track is laid on temporary line at an expense of about $8000.

"There have been nine trestles erected (two on temporary line) of a total length of 1453 feet, which have cost $7500. There are twenty-one miles cleared of timber.

"In order to obtain the information we have, we have been obliged to run about 160 miles of trial line.

"The locating party under Mr. Byers is composed principally of Bolivian Indians, there being seven whites and twenty-five Indians. These do the duty of axemen, move the camp and transport provisions from San Antonio.

"On the first six miles there will be 158,500 cubic yards of excavation, about two-thirds of which will be paid for as rock or shale, and 175,000 cubic yards of embankment. On the remaining distance the quantities will probably average from 10,000 to 15,000 cubic yards of material to be moved per mile. There will probably be required on the average one culvert per mile, for which I should propose using iron pipe.

"The only bridging we are sure of is 150 lin. feet at station 30, and 350 lin. feet at station 2740, over the Jaci Parana River, though we may have to bridge some of the smaller streams—at most, three or four of them. There is but little stone to be obtained anywhere, except at San Antonio and Theotonio Falls. At the latter place the stone is already cut and bedded by nature.

. . . .

Your obedient servant,

C. S. D'Invilliers, *Chief Engineer*."

Engineers' Club of Philadelphia.

LIST OF MEMBERS.

With address and date of election.

NOTE.—Members are requested to promptly report any change from this list to the Secretary.

HONORARY MEMBERS.

ROBINSON, MONCURE, C. E. 1319 Spruce St., Phila. April 6th, 1878.

HAUPT, Gen. HERMAN, C. E. 328 Walnut St., Phila. April 6th, 1878.

CORRESPONDING MEMBERS.

CHRISTIE, JAMES, Mech. Eng. Pencoyd Iron Works, 265 S. Fourth street, Philadelphia. February 16th, 1878.

FLETCHER, ROBERT, C. E. Professor Civil Engineering, Dartmouth College, Hanover, N. H. April 6th, 1878.

FRY, HOWARD. Superintendent motive power, P. & E. R. R., Williamsport, Pa. February 16th, 1878.

LEE, R. H. Superintendent Logan Iron and Steel Co., Lewistown, Pa. February 16th, 1878.

NICHOLS, EDWARD. Tarrytown, N. Y. February 16th, 1878.

ROBINSON, J. F., Mech. Eng. Atlas Works, Manchester, England. April 6th, 1878.

SCHENCK, A. A., C. E. 4006 Baltimore Ave., Phila. Feb. 16th, 1878.

TARR, H. G. H. Slateford, Northampton Co., Pa. Feb. 16th, 1878.

MEMBERS.

ASHBURNER, CHAS. A., M. S. Asst. in charge Second Geol. Sur. Pa., 907 Walnut street, Phila. December 17th, 1876.

BEARDSLEY, ARTHUR, C. E., Prof. Mechanics. and Civ. Eng., Swarthmore College, Swarthmore, Pa. January 18th, 1879.

BILLIN, CHARLES E., C. E. 4039 Locust street. Dec. 17th, 1877.

BONZANO, M. F., C. E. Asst. Eng. P. W. & B. R. R. Mar. 1st, 1879.

BURNHAM, GEORGE, C. E. Stowe Flexible Shaft Co., 500 N. 15th street. Dec. 17th, 1877.

BURNHAM, WILLIAM. Treas. Standard Steel Works, 220 S. 4th St. Dec. 17th, 1877.

BUZBY, CHAS. E., Mech. Eng. 220 S. Fourth St. April 6th, 1878.

CARTWRIGHT, HENRY, C. E. Prest. Penn Gas Coal Co., 2107 Green street. January 18th, 1879.

CHAUVENET, S. H., C. E. Penna. Steel Co., Baldwin, Pa. Jan. 18, '79.

CHRISTIAN, GEORGE H., JR. Assistant Eng. Elyria Gas Light Co., Elyria, Ohio. Dec. 17th, 1877.

CLARKE, THOMAS C., C. E. Clarke, Reeves & Co., 410 Walnut St. Feb. 2d, 1878.

CLEEMANN, THOS. M., C. E. Asst. Eng. Phila. Water Department, April 20th, 1878.

CODMAN, JOHN E., Mech. Eng. Phila. Water Dept. Jan. 17th, '79.

COLTON, OREN B., C. E. 2009 Wallace street. Dec. 17th, 1877.

CONSTABLE, HOWARD, C. E. 1820 DeLancey Place. Feb. 16th, 1878.

COOPER, WILLIAM A. 500 N. Fifteenth street. Feb. 16th, 1878.

CRAMP, CHARLES H. Wm. Cramp & Sons, shipbuilders, Beach and and Norris streets. January 18th, 1879.

CRANMER, W. C., C. E. 1918 Christian street. Jan. 18th, 1879.

DARRACH, CHAS. G., C. E. Asst. Eng. Phila. Water Department. April 20th, 1878.

FRANCIS, HARRY C., Mech. Eng. 1600 Hamilton St. Mar. 1st, '79.

GEST, ALEXANDER P., C. E. Asst. Eng. Penna. R. R., 1231 Spruce street. March 1st, 1879.

GRAFF, FREDERICK, Hydraulic Eng. 1331 Arch St. Jan. 18th, '79.

HARDIN, JOHN Hy, Min. Eng. Instructor Min. Eng. University of Penna. Jan. 18th, 1879.

HAUPT, LEWIS M., C. E. Prof. Civil Eng. Towne Scientific School University of Penna. Dec. 17th, 1877.

HERING, RUDOLPH, C. E. Asst. Eng. Dept. of Surveys, Phila. Feb. 2d, 1878.

HOOPES, HERMAN, C. E. 1534 Arch street. Dec. 17th, 1877.

HOWELL, EDWARD J. H., Mech. Eng. 4636 Germantown avenue. Jan. 18th, 1879.

INGHAM, WM. A., Min. Eng. President Rockhill Iron and Coal Co., 320 Walnut street. Feb. 2d, 1878.

KNEASS, STRICKLAND, C. E. Asst. to Prest. Penna. R. R. Jan. 18, '79.

[1] KNIGHT, J. B., Mech. Eng. Sect. Franklin Institute. Jan 18, '79.

LEHMAN, A. E , Min. Eng. Asst. Second Geological Sur. of Penna. 524 Walnut street. Feb. 2d, 1878.

LEWIS, HENRY C., Min. Eng. E. Washington Lane, Germantown. Dec. 17th, 1877.

LEWIS, THEO. J., Mech. Eng. 2224 Green street. Dec. 17th, 1877.

LEWIS, WILFRED, Mech. Eng. 33d and Powelton ave. Dec. 17th, '77.

MARKS, WM. D., Ph.D. Whitney Professor of Dynamical Eng. University of Penna. Feb. 2d, 1878.

MADEIRA, LEWIS C. JR., C. E. 322 Walnut St. Feb 16th, 1878.

MCCLELLAN, O. E., C. E. Supt. Penna. R. R. Co. Grain Elevator, Washington street wharf. Mar. 1st, 1879.

MCCOLLOM, T. C., C. E. Eng. of Gov't Works, League Island, Phila. April 20th, 1878.

MCFADDEN, WM. H. Chief Eng. Phila. Water Dept. Jan. 18th, '79.

MOORE, CHAS. F., C. E. 1507 Fairmount Ave. Mar. 1st, 1879.

MORRIS, H. G., Mech. Eng. 200 S. Third St. Feb. 2, 1878.

MORRIS, J. W., C. E. Lehigh Valley R R. office, 238 S. Third St. April 20th, 1878.

MUCKLE M. R. JR., Mech. Eng. 1722 Pine street. Dec. 17th, 1877.

MURPHY, HOWARD, C. E. Asst. Eng. Dept. of Surveys, Phila. Mar. 16th, 1878.

NEILSON, W. G., Mech. Eng. General Manager Standard Steel Works. Dec. 17th, 1877.

NORRIS, THADDEUS, Mech. Eng. 221 S. 18th St. April 20th, 1878.

PARRISH EDWARD, C. E. Asst. Light House Eng., 4th District, 532 Walnut street. Jan. 18th, 1878.

POTTS, WM. M., C. E. Eng. in charge of Improvements at Girard Point, Phila. Feb. 2d, 1878.

REYNOLDS, Brig.-Gen. WM. F. U. S. Corps Engineers, 532 Walnut street. Mar. 1st, 1879.

ROBERTS, A. R., C. E. Asst. Eng. North Penn. R. R. Feb. 2d, '78.

ROBERTS, PERCIVAL. Pencoyd Iron Works, 265 S. Fourth street. Mar. 1st, 1879.

[1] Deceased.

ROBERTS, PERCIVAL, JR., Mech. Eng. 265 S. 4th St. Dec. 17th, '77.

ROGERS, FAIRMAN, C. E. 202 W. Rittenhouse Square. Feb. 2d, '78.

SAMUEL, EDWARD. 332 Walnut street Mar. 16th, 1878.

SANDERS, R. H. 615 Walnut street. Jan. 18th, 1879.

SELLERS, COLEMAN, JR., Mech. Eng. 3301 Baring St. Dec. 17th, 77.

SELLERS, HOWARD, Mech. Eng. 3300 Arch St. Dec. 17th, 1877.

SELLERS, HORACE W., Mech. Eng. 3301 Baring St. Dec. 17th, '77.

SELLERS, WM. F., Mech. Eng. 1819 Vine St. Dec. 17th, 1877.

SHEAFER, ARTHUR W., C. E. and Min. Eng. 907 Walnut street. Mar. 1st, 1879.

SMEDLEY, SAMUEL L., C. E. Chief Eng. Dept. Sur. Jan. 18th, '79.

SOULE, RICHARD H., C. E. Asst. Eng. Penna. R. R., Altoona, Pa. Jan. 18th, 1879.

STAUFFER, D. McN., C. E. Asst. Eng. Phila. Water Department. Feb. 2d, 1878.

TAYLOR, FRED. W., Mech. Eng. Midvale Steel Works, Nicetown, Phila. April 20th, 1878.

TITLOW, J. MILTON, C. E. Prin. Asst. Eng. Dept. of Surveys. Jan. 18th, 1879.

TOWNSEND, JOHN W. Asst. Eng. Cambria Iron Co., 218 S. 3d St. October 5th, 1878.

VEZIN, HENRY A., C. E. Standard Steel Works, 220 S. 4th St. Jan. 18th, 1879.

WARREN, B. F., C. E. 1706 Wallace St. Feb. 16th, 1878.

WEBSTER, GEO. S., C. E. Asst. Eng. Dept. of Sur. Jan. 18th, 1879.

WHARTON, WM. R., C. E. 2107 W. DeLancey Place. Jan. 18, '79.

WILSON, JOHN A., C. E. 410 Walnut St. Jan. 18th, 1879.

YOUNG, CHAS. A., Min. Eng. 536 N. 4th St. Dec. 17th, 1877.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

THE FUTURE OF AMERICAN ENGINEERING.

ADDRESS BY THOMAS C. CLARKE, PRESIDENT.

Read April 19th, 1879.

GENTLEMEN:—I have chosen this subject for my address, as I know of none more personally interesting to the members of this Club, most of whom are young men who look forward to many years' practice of their profession, and whose career will be greatly influenced by the future of American Engineering.

The numbers of our profession are increased every year by hundreds of graduates from the technical and scientific schools, and by others who rise from the ranks of the great army of labor to become its leaders. All of them expect to make engineering, in some of its various branches, the profession and occupation of their lives; and all are interested to know whether there will be room and work for all.

One's first demand of his profession is that it shall give him an honest living.

His next strongest wish is to find an opportunity to execute some work that shall fully call out his abilities, and give him some measure of that fame which we all prize.

Finally, he ought to wish to "pay the debt which every man owes to his profession" by making some permanent addition to knowledge, either in engineering itself or in some of its kindred sciences.

If a man succeeds in but one of these three things he may be thankful; if in all, he may justly claim the title of an "eminent engineer."

The broadest and at the same time most concise definition of engineering is "scientific construction." If this be true, engineers have existed from the days when the early kings of Egypt reared the first pyramids, a thousand years before Abraham was born, down to

the generation which has seen the achievements of Stephenson, of Morse, and of Eads.

But while engineers have lived and labored for so long a time, it is only of late years that they have become a distinct guild and profession. The name was first applied to the makers of canals, aqueducts, dykes, jetties, and other hydraulic constructions. Then, it was extended to the makers of railways, and now, it takes in a much wider range of operations. It will be attempted to show that on the breadth and inclusiveness of this classification depends the solution of the problem of the future success of our profession.

The first question is: What preparation and education will best make a man a scientific constructor?

A great deal of discussion has taken place during the last year or two on the education of engineers. It is not intended to enlarge upon this here. Suffice it to say that we are all now agreed that education is of two kinds, that derived from books, and that obtained from actual practice and from contact with men.

One tells us what to do, the other how to do it.

Both kinds are absolutely necessary.

The more of the first kind an engineer has, or in other words, the broader and deeper the foundations of his knowledge are laid, the more readily and intelligently will he acquire the second, and the more satisfactory will be the results of his practice.

But in order that his learning may be of practical use to him, he must also have experience.

The young engineer of the present day comes to his work with a much better preparation than those of the generation before him. He must not, however, make the mistake of supposing that the eminent engineers of a past generation, who never enjoyed the privileges of the schools, were deficient in scientific knowledge. They had it, but they got it from actual experiment, and went beyond the books of their day, and were in many cases the original discoverers and investigators, the fruits of whose labor every school-boy can now enjoy.

The weak point of the old system was, that while it produced many great men, yet the average did not stand as high as now; and the expenditure of much capital had to be entrusted to ignorant persons, whose blunders led to enormous waste, and whose names are now happily forgotten, together with their mistakes.

The young engineer of the present day should also remember that

now, as in the past, there is but one road to success. He who wishes to command must first learn to obey. He must show his superior officers that he is perfectly reliable and faithful. A man who has his mind occupied with the direction of large interests appreciates fully the wisdom of the saying, "Never do yourself what you can get any one else to do for you." But this cannot be carried out unless he feels perfectly sure that his assistants will not deceive him, that they will report things exactly as they are and will carry out his instructions to the letter.

After a young man has shown that he can always be depended upon, he will soon be promoted into a higher rank, where the orders are more general and where more is left to his discretion and judgment.

If to faithfulness and energy he adds good judgment, and to good judgment tact, and the power of managing and controlling men, he may rest assured that before very long he will have gained the first requisite—material success.

He will probably find that soon an opportunity will offer to carry out some work which will ensure him a measure of reputation.

Finally, his early scientific training having taught him to observe facts and draw deductions therefrom, he will probably, sooner or later, make some contribution to science. Even if not a writer, he will furnish some of the material of which books are made.

We have thus briefly traced the career of a successful engineer in the present condition of the profession, or rather in the immediate past.

But it will be said: "The ranks are already too crowded. More and more men are coming in every day. Although we admit the truth of Webster's saying, 'there is always room at the top,' yet, what shall we do who are men of only moderate abilities? We do not ask nor expect the great prizes of the profession, but we cannot help thinking that in America engineers are less esteemed and less paid than in any other civilized country of the world. Will we be better or worse off in the future? Are we going up grade or down?"

These are very pertinent questions, and a true answer would be of the highest interest. I will endeavor to give you my views, always bearing in mind the modest epitaph of the old surveyor, "his hind-sight was better than his fore-sight."

It has been previously stated that on the breadth and inclusiveness of the classification of engineers depends the solution of the problem of their future success.

If we bear in mind that while an engineer is, unfortunately, not

always a scientific constructor, yet a scientific constructor *must* be an engineer, we shall see how numerous are the paths open to us to follow and how soon the crowd will be relieved.

Let us see how the number of these paths has increased during the last half century.

Before the year 1828, an engineer meant a man who knew how to make canals and water-works.

But when George Stephenson created the modern railway, an engineer soon came to mean a man who could build railroads. The construction of the 85,000 miles of railroads in the United States, costing over 4,500,000,000 of dollars, has naturally given employment to the largest number of engineers. After these roads were opened for use, they still continued to employ many engineers in taking care of them and of operating them.

Within the last dozen years, the substitution of iron for wood, first in railway bridges and viaducts, and afterwards in structures of all kinds, has developed another class of special engineers, who, being of a pushing and energetic disposition, have, perhaps, monopolized rather more than their share of public attention.

The development of our mineral wealth, in which it is estimated that over 400,000,000 of dollars have been invested during the last thirty years, may be seen reflected in the list of the Society of Mining Engineers, which numbers 734 members.

Then we have the engineers of the water-works, drainage, sewerage and of the streets and structures of our large cities. The city of Boston is now expending some 5,000,000 of dollars in its improved sewerage, surpassing, in some respects, even the gigantic works of London itself.

Mr. Chesbrough, city engineer of Chicago, was once introduced to one of the European engineering societies as that daring engineer who had raised a city of 300,000 people ten feet up in the air above its original position.

Allied to the preceding class we have the sanitary engineers, specialists, whose duty it is to apply scientific principles to the construction of our dwellings, too long left in the hands of ignorant plumbers and builders.

Then we have the honorable body of architects, who all ought to be engineers, *i. e.* scientific constructors; for, if they are not, so much the worse are their buildings.

The great gas companies now almost always employ men of scientific attainments as their engineers, the result of whose labors may be seen rather in the increase of dividends than in the lower price of gas.

But another school of specialists is coming on whose labors will correct all this—the electric engineers, whose skill has already enabled us to light our workshops more brilliantly and at less cost than the gas engineers have been able to do it.

The future of electric engineering includes not only the vast fields of electric lighting and of the telegraph, but all means of transmitting signals and, perhaps, of power.

Another class of specialists has an enormous future before it in this country—I mean agricultural engineers, who, as a separate body, have existed for some years in England. When one considers the great savings that are capable of being made by the application of correct scientific principles and practice to farming operations, which are now done so loosely and by rule of thumb, who will not say that here is not a great opening for engineers in the near future?

Then there is a class of engineers whose services are more and more in demand every year—I mean the engineers employed by large contractors. Some of the ablest men in England are contractors' engineers.

You will observe that for a man to succeed in any of these newer branches of our profession he must be much more than a mere surveyor or designer and measurer of masonry and earthworks. He must be, first and foremost, a mechanical engineer, as it is termed. He must understand dynamics as well as statics, and must be practically familiar with the construction of machinery and machine tools.

In Europe no man can attain eminence as a civil engineer who is not well versed in the mechanical part of his profession. Hence, we find them constantly called upon to design, construct and report upon paper mills, cotton factories, sugar machinery, iron and steel works and such things, which in this country are entrusted to manufacturers rather than to engineers.

I do not mean to say that this country is behind others in mechanical engineering—the names of Fritz and Griffen, of Sellers and Holly, forbid that; but I do mean to say that if American engineers, as a class, were better versed in the mechanical part of their profession, they would not see themselves laid on the shelf by the capitalists who throw away their money on Keeley motors.

It was one of the traditions of the elder school of engineers that they should carefully abstain from taking part in matters of business. Architects and civil engineers were formerly either government officials or, as professional men, they held the same social position, which they feared would be lowered if they became business men, skilled in prices and sharp at a bargain. This was merely a survival of the old feeling of contempt which the governing classes—the men of the sword—felt for the men of affairs.

The effects of this mischievous tradition has descended to our own day, with unhappy results to the profession. I need scarcely tell you that an engineer is only half fitted for his work unless he is able to hire men and buy materials and execute his own designs, if occasion calls for it. It may seldom be necessary for him to do it, but the ability of so doing makes him a better judge of the value of a contractor's work, and a far safer estimator of the probable cost of public works.

European engineers profess to be able to do this, and this is one reason why they command their five per cent. commission on the cost of their works, and attain wealth and position, while, in this country, engineers are too often paid the salaries of second-rate clerks.

It has sometimes happened that, in looking for the engineer of some railroad, I have been disgusted to discover him at last hidden away in a dusty office on the upper story of a building, ignored by almost everybody; while the ticket agents, and the fast-freight agents, and the palace-car agents, and all their tribe, sit down-stairs in splendid apartments, drawing large salaries and commissions, and evidently people of the highest consideration. This is because they are first-class business men, while the poor engineer is not.

Let the engineers of the future, if they wish to prosper, learn to be men of business and control the cheque-book and the ledger. We shall then hear less of public works frightfully overrunning the original estimate of cost, and the whole profession will stand higher in public estimation. Pardon me if I say that I feel sure that whatever reputation I myself have is due to the fact that the public feel confident that I can and will execute my own designs within my estimates both of cost and time.

From what has been said you will see that my views of the future prospects of engineering in America are not gloomy.

The truth is, that it is by engineers, whether called by that name or

not, that America has been made what she is to-day. The Fultons, the Morses, the Ericssons, the Howes, the McCormacks and the Edisons are engineers, although their names may never have been enrolled on the lists of learned societies; while among those whose names are to be found on such lists, who is there in any country who ranks above Jervis, Latrobe and Eads?

Follow, therefore, in their footsteps. The field is vast, for it covers the whole area of scientific construction, while the laborers are even yet but few. From the brilliancy of the past we may predict the greater glories of the future. Some of us who are passing off the stage may not live to see them, but there are young men in this room who may one day behold greater triumphs of engineering than the world has yet seen.

XI.

THE NEW RIVER COAL FIELD, WEST VIRGINIA,

ALONG THE LINE OF THE CHESAPEAKE AND OHIO R.R.

By CHAS. A. YOUNG, Geologist, Member of the Club.

Read February 1st, 1879.

The New River, rising in the northern part of North Carolina, and flowing in a course north by a few degrees west through Virginia and West Virginia, receives in Fayette county, in the latter State, the Gauley River, and then, under the name Kanawha, flows northwest, emptying into the Ohio River opposite Gallipolis, Ohio.

In Virginia the river passes through the sub-carboniferous coal field of Montgomery county, represented in Pennsylvania by the small seams in Huntingdon county described by Mr. Ashburner, though differing greatly from them in point of size; for while the Pennsylvania seams are so small as to be a matter of interest to the geologist only, the beds in Virginia are workable.

Passing down the river we enter, in Raleigh county, West Virginia, the field of the intra-conglomerate coals, not represented at all in Pennsylvania, yet forming in the region under consideration a deposit of great importance, which is making itself felt in the coal and the iron market of the country, and which is destined to play a still more important part in the metallurgical development of the South and West. It is to this coal field that I wish to call the attention of the Club.

Prof. Fontaine has called these beds the "New River Series"; but, as that name had been given several years ago by Prof. Lesley to the previously mentioned beds in Montgomery county, Va., the latter gentleman has given the name of "Kanawha Series" to the intra-conglomerate coals. No confusion can arise from the use of this title, for this coal field really extends to the valley of the Great Kanawha, while the coals shown along that stream lower down and along the greater part of its course, are those so well developed in Pennsylvania along the Allegheny and the Monongahela River, and so thoroughly described in the reports of the geological surveys of our State.

The Chesapeake and Ohio Railroad enters the valley of the New River at Hinton, Greenbrier county, W. Va. The river flows through a cañon rather than a valley, the bottom land, bordering on the stream, being in many places only fifty or a hundred feet in width on each side, and rarely as much as a quarter of a mile, while the sides of the gorge rise precipitously to the height of 800 or 1000 feet. When these steep slopes are climbed, a rolling country cut by numerous streams is reached. These streams do not have a rapid fall until they approach very near to the river. To the observer stationed a mile or two back from the cañon, there is nothing to suggest that the main stream of the region lies a thousand feet below him. In many places along the river it is possible to ascend to the upper country only by means of the natural passes afforded by the tributary streams. There are stretches of several miles in which not a single wagon road comes down to the river.

Some notion of the rugged character of the country may be gathered from the fact that when, about four years ago, the traffic along the railroad was interrupted by numerous landslides, the settlement at Quinnimont Furnace, containing between two hundred and three hundred persons, was dependent for its supplies upon trains of pack mules, there being no wagon road over which goods could be hauled.

From Hinton to Kanawha Falls, a distance of sixty miles (a few miles below the confluence of the New and the Gauley, forming the Kanawha), the river flows through the measures of the Pottsville Conglomerate (XII, Seral Conglomerate of Rogers). This formation is here made up of several plates of massive sandstone, not often conglomeritic, and strata of shales and slates, in which the coal beds are found.

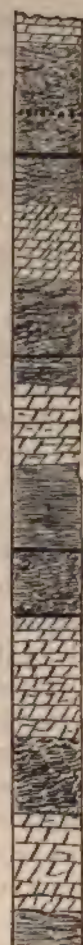
The strata of massive sandstone form lines of bold cliffs along the

sides of the gorge, often extending for thousands of feet without a break in their vertical walls through which an ascent can be made.

It is one of the lower plates of this sandstone which forms the barrier over which the New River falls a few miles below Hinton, while the Kanawha rushes over one of the upper ones at Kanawha Falls, sixty miles further down stream. The vertical sections accompanying this paper show clearly the occurrence of these sandstone strata which serve as key rocks to the geologist in his examinations.

DIMMOCK SIDING.

BOWYER'S FERRY.



At Quinnimont the existence of an anticlinal is plainly shown by the deep cutting of the river into the Mauch Chunk Shales (XI, Umbral Red Shales of Rogers). At this point the conglomerate is between five hundred and six hundred feet above the river. A short distance beyond Quinnimont the gray calcareous shales, called "Transition Series" by Prof. Fontaine, and representing the subcarboniferous or mountain limestone of southwestern Pennsylvania, are shown very distinctly, the line between them and the red shale below and the conglomerate above being very clearly defined.

Four workable beds of coal outcrop along the sides of the gorge of the river. The sections, page 127, made opposite Dimmock's Siding and Sewell Station (Bowyer's Ferry), show the place of the coal beds in the measures. The points at which the sections were made are five miles apart, Sewell being below (northwest of) Dimmock. The vertical distances were measured by means of an aneroid barometer; and no account is taken of the influence of the dip, here very gentle, in a direction north 60 degrees west.

The coal is bright and clean, containing very little slate or sulphur (pyrite). It is soft, and can be easily mined without blasting.

Coking is carried on at several points along the river.

The bee-hive pattern of oven is used exclusively. The ovens of one firm have a flue around the in-wall, thus allowing an even supply of air, and one much better regulated than by the ordinary way of admitting the draft at the door.

Owing to the purity of the coal, washing is not necessary; and the oven receives the product of the mine direct from the cars.

The coke is bright, firm and coherent, and closely resembles the celebrated product of the Connellsville region. There are only four coke works in the region—Quinnimont, Fire Creek, Sewell and Nutallburg. The coke made at Quinnimont is used in the furnace at that place. That made at Sewell is shipped to the furnace of the Longdale Coal and Iron Company, in Allegheny county, Va. The rest of the product finds its market in the Ohio Valley.

The following analysis of the coal was made by Prof. Ricketts, School of Mines, New York:

Moisture,	·610
Volatile matter,	22·345
Fixed carbon,	75·020
Ash,	1·465
Sulphur,	·560
	100·000

The specimen analyzed was from the Fire Creek mine. An examination of the "run of the mine," as loaded on the cars for shipment, shows the freedom of the coal from those impurities which can so often be detected by the eye.

The coal is shipped to tide-water at Richmond for a steam fuel.

Mr. J. M. McFarland, Master of Machinery, C. & O. R.R., made an examination of the steam-raising power of the coal from the same mine with the following results:

Duration of trial, ...	9·5 hours.
Water evaporated, . . .	9506.25 lbs.
Temperature of feed water, . .	57° (F.)
Fuel consumed, . . .	1241 lbs.
Percentage of ash, ...	2·38 per cent.
Quantity of water evaporated per pound of coal,	7·66 lbs.
Steam pressure, ...	30 lbs.

As the coal lies high in the hills, long and often steep inclined planes are used to bring it to railroad grade. This of course increases the expense of opening a mine; but as the numerous ravines offer an opportunity to attack the coal in almost any direction, a self-draining mine acts as an offset to the elevated position. Lower down the river, the dip of the measures brings the coal to a more convenient distance from the river.

The iron ore shown in the Bowyer's Ferry section has not been developed beyond a slight picking into the outcrop at one point. The outcrop was stripped until a compact bed of lumpy brown hematite, four feet thick, was exposed. The deposit was then too hard and compact for the pickaxes of the prospectors, and work was abandoned. The bed is probably the lumpy blue carbonate, weathered to a hematite on the outcrop. In the Dimmock's Siding section the ore was not seen as a bed; but a ferruginous shale, thickly covering the ground with small pieces of ore, occupied the same horizon. This shale is a strongly marked feature in this point of the measures.

The massive sandstone can be quarried at any point, and furnishes to the engineer an unlimited supply of material for first-class masonry.

Timber of all kinds, except pine, abounds.

The only outlet to this region is the Chesapeake and Ohio Railroad; but projects are afoot which will still further open this coal field to the outside world.

South and west of this district lies a vast country almost a *terra incognita* to the engineer, yet only biding its time, to offer to him an ever extending field.

XII.

SOME FEATURES OF ANCIENT ENGINEERING.

By George Burnham, Jr., C. E., Member of the Club.

Read February 15th, 1879.

Modern research among the ruins of antiquity is steadily relegating to the old civilization many things that we formerly thought belonged only to modern times. Almost all the *materies* of our present civilization originated among the ancients, the peculiar distinction of modern times being the wider and more rapid diffusion of our inheritance from the past and the working it over into new forms. The various textile fabrics of cotton, linen, silk and wool that we now use, for example, were perfectly well known to the Egyptians of 4000 years ago; but the cotton gin, the power loom and the steam engine have increased their forms and variety and put them into the hands of every one. We find the same thing true of engineering science. Canals, artificial harbors, stone bridges, aqueducts, drainage systems, high class roads, involving cuttings, embankments and tunnels, and stone, brick and wooden building construction of all varieties existed then as now; but the modern engineering methods differ widely from those employed by the ancients. The ancient harbor of Ostia, a magnificent work, protected from the sea triremes and craft well adapted only for navigation in the Mediterranean, while the stone docks of Liverpool harbor the ocean steamer and the enormous iron clad man-of-war. The substructure of the modern railroad is very much the same as the old Roman military road, but in our hands its scope and efficiency have been vastly increased. A recent engineering achievement, the transport of an Egyptian obelisk from Alexandria to London, and its erection on the Thames embankment, illustrates very well, I think, our indebtedness to antiquity, and not less our progress. That we should, in this nineteenth century, re-erect, with pomp and ceremony, a monument set up in Egypt ages ago, is the strongest kind of a compliment to the ancients. It may well be doubted whether our successors of twenty-five centuries hence will think any of our efforts of this kind worth carrying 4000 miles and re-erecting. Of the manner in which it was accomplished—the iron caisson-like boat, so admirably

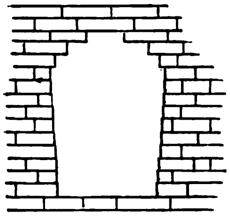
designed; the ease with which it was swung on its iron trunnions and placed on its pedestal—we may justly feel proud; still the fact remains that the *fait accompli*, the end reached, was the same as that of its original designer. How the Egyptians raised their obelisks we do not yet know, beyond the fact that they were familiar with the simple machines, the inclined plane, etc.; understood the use of cordage, and had command of unlimited manual labor in the shape of captives taken in war.

We should naturally expect to find the constructive uses of the simpler building materials, stone, brick and wood, highly developed among the ancients, and this we find to be the case. In this direction I shall consider, first, the structures found in Western Asia.

The earliest civilizaton in this region of which we have any records was the Chaldean, and was central in the lower part of the Tigris-Euphrates valley. This region is alluvial in character, with no stone, but abundance of clay, and was subject to frequent inundation. The building material, consequently, was mainly brick, and the important structures were built on platforms raised above the general level of the plain. The temple at Mughier was built with parallel sides of 98 feet and 133 feet in length, and about 40 feet high. The material used was small sun-dried brick, laid in bitumen, faced with kiln-dried brick. The bricks of the upper story were laid in a cement of lime and ashes. The bricks used in this and similar structures were stamped with the name of the king. In the uppermost story glazed tiles and copper nails have been discovered. The temple of Abu Shahrein (these, of course, are modern names) rests on a platform of beaten clay, cased with a massive wall of sandstone and limestone, 20 feet thick in places. From the platform to the summit of the first story extends a marble staircase, composed of small polished blocks, 22 in. × 13 in. × 4½ in., fastened by copper bolts to the bed of sun-dried bricks, on which the staircase rests.

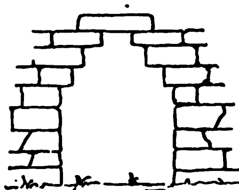
Of these edifices Rawlinson says: "No buildings in the world, not even the Pyramids, are more deficient in external ornament. The buttresses and air-holes, that alone break the uniformity of the walls, are intended for utility only." A brick burial vault at Mugheir is interesting, as exhibiting what we may call a rudimentary arch. The vault is of sun-dried brick, laid in mud, 7 feet long, 3′ 7″ wide, and 5 feet high. The sides slope gently outwards as they ascend until

Fig. 1



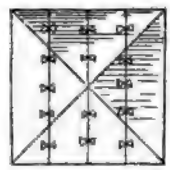
Chaldean Burial Vault—Brick

Fig. 8.



Greek Postern

Fig. 7.



Roof of Persian Tower

Fig. 4.

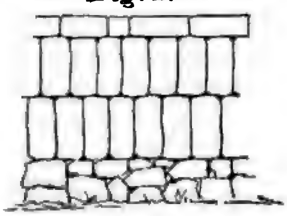
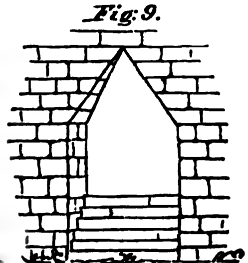
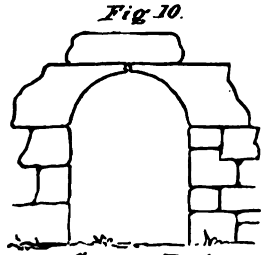


Fig. 9.



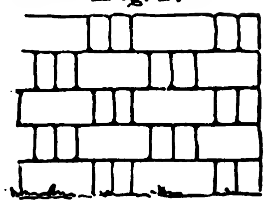
Greek-Postern

Fig. 10.



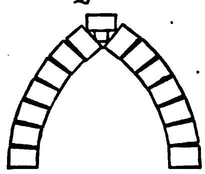
Greek Postern

Fig. 2.



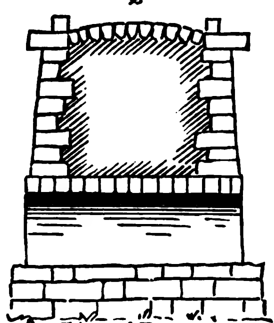
Elevation -

Fig. 5.



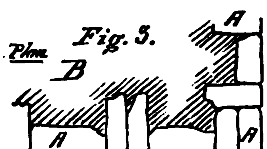
Arched Drain-Brick

Fig. 11.



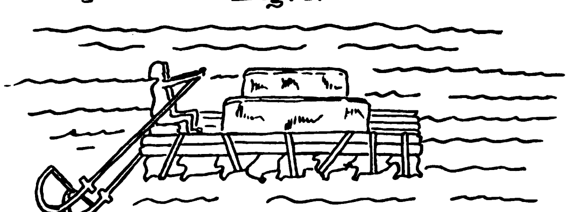
Section of Roman Road through Culvert

Fig. 3.



Assyrian Masonry-(Khorsabad)
AA- Stone
B- Brick backing

Fig. 6.



Transporting Stone—Assyrian bas relief at Kuyunjik

the springing line is reached, when the successive layers of brick are pushed towards each other until they meet.[1]

The Chaldean ascendency in the East lasted from about 2200 to 1500 B. C., after which time the Assyrians became masters of the situation, remaining so until about 650 B. C. The centre of activity now advanced to the upper portion of the Tigris-Euphrates valley. At Nineveh, according to Diodorus, the wall surrounding the city was 100 feet high, and so broad that three chariots might drive around side by side. Xenophon, who passed close by on his famous retreat with the ten thousand, puts the height at 150 feet and the width at 50 feet. The actual greatest height of the ruins at present is 46 feet, and, from the immense mass of débris, the computation of Diodorus is probably not far from the truth. The width of the crumbled mass is from 100 to 200 feet. The construction seems to have been as follows: up to a certain height (50 feet, according to Xenophon) the walls were composed of neatly hewn blocks of fossiliferous limestone, smoothed and polished on the outside. Above this the material was sun-dried bricks. The grand halls of the Assyrian palaces constituted their principal feature. In the palace of Esarhaddon, the son of Sennacherib, the hall was intended to surpass all its predecessors. Its length was to be 165 feet, its breadth 62 feet, making an area of over 10,000 square feet. The builder appears to have been unable to roof the hall, and was obliged to divide it by a wall down the middle, which, though he broke it in an unusual way, and kept it some distance from the ends of the apartment, still had the actual effect of subdividing the room. The method of roofing these palaces is not certainly known; some investigators holding that brick vaulting was used, while others think that wooden beams were employed. Others, again, imagine that the portions near the walls, only, were covered; leaving the centre open for light and air.

The masonry at Khorsabad was of three kinds: That of the palace mound, forming a portion of the outer defence, was composed entirely of stone, square hewn, of great size, laid dry and backed with brick. Figs. 2 and 3 show an elevation and horizontal section of this wall. The bond is made up of stretchers, alternating with double headers; the re-inforced corner and the bonding of the stone into the brick backing are points worthy of notice. The stones measure from two to three yards in length, three feet in width, aud five to six feet in height.

[1] Compare Figs. 8, 9, 10, representing early Greek construction.

The rest of the defences were of inferior character. The material was stone, but not so carefully hewn. The third kind, illustrated in Fig. 4, was found outside the main wall. Stone only was used, the lowest course being rough rubble work; above this were two courses of carefully squared stones, about one foot long and six inches wide, placed on end, care being taken to break joints.

Although the ancient architectural construction was mainly trabeate in its nature, the old notion that the round arch was of Roman and the pointed arch of Gothic origin has been dissipated by the spade of the Eastern archæologist. I have already spoken of the elementary arch of the Chaldeans, but the Assyrians used the true arch. All the Assyrian arches hitherto unearthed are of brick. Round arches are found both in crude and kiln-dried material, the bricks, in every case, having the proper wedge-shape section, with curved extrados and intrados. These arches are almost wholly found in underground construction, as drains, etc., the greatest span hitherto discovered being fifteen feet. They are mostly semi-circular. The only pointed arch found by Mr. Layard is in a drain under the N. W. Palace of Nimrud and is very peculiar in its construction. The bricks used are ordinary rectangular brick, laid as in Fig. 5. The arch is keyed with two layers of brick with their beds horizontal. The mortar joints are, of course, slightly wedge-shaped.

The faults of Assyrian construction are not less interesting than its merits. Although there was plenty of stone at hand, they used sun-dried brick, merely faced with stone, because they had learned a certain style in the alluvial Babylonia, and having brought it with them to a country far less fitted for it, they raised in comparatively hilly Assyria the type of building that was the natural outgrowth of the flat, stoneless plain that was their primitive abode. The earthen platforms upon which they built must inevitably have bulged and settled sooner or later; the problem of the retaining wall that still troubles the engineer proved fatal to many an Assyrian constructor.

Hence, while the massive buildings of Egypt stand to-day, the Assyrian palaces are almost shapeless ruins. That the Assyrian king so frequently destroyed the palace of his predecessor, and built afresh, is probably due to the rapid decay of the edifice rather than a mere desire to excel his forerunner. That they found no difficulty in transporting large stones is evidenced by their bas reliefs. Fig. 5, taken from a bas relief at Koyunjik, shows a boat loaded with such freight pro-

ceeding down a river. The lower part of the craft is made of inflated skins, to which are lashed logs for the flooring.

The colossal human-headed bulls, of such frequent occurrence in Assyrian art, and which weighed many tons, were placed on the top of artificial platforms, from thirty to eighty feet high. From the fact that they finished the detail of the statue before transport shows that they were perfectly confident of their ability to move it without mishap. The bas reliefs illustrate in the most detailed manner the way in which this was effected. The colossus was placed on a huge wooden sled and was cased with a network of spars, crossing at right angles, lashed at the intersections. In this casing the figure was carefully wedged to prevent any motion. Guy ropes were attached to the top of the casing and were held taut by parties of laborers on either side. Besides these, wooden forks or props were applied lower down, also held by parties of men. The front of the sledge was curved upward, to enable it to rise easily upon the wooden rollers continually placed before it. The motive power was applied by large cables, to which gangs of men were attached by straps passing over one shoulder and under the other and fastened to the main cables, an arrangement enabling them to use their weight and strength to the best advantage. The cables were fastened to the sledge at four projecting pins or trunnions by a knot of peculiar construction. To start the mass a large wooden lever was applied behind. To get the full benefit of the lever, ropes were fastened to the upper end, which could not otherwise have been reached. An Egyptian sculpture near El Bersheh shows a colossal statue in process of transport, the means employed being very similar to the foregoing. On the knees of the figure stands a man, probably beating time and giving out the words of a song. At the prow of the sledge a man is pouring something from a vase, perhaps grease. Platoons of soldiers accompany the march. A number of men are delineated carrying water (or possibly grease) and unknown implements. Task masters and reliefs of men follow. We have seen that the Assyrians, who came into power 1150 B.C., knew the brick arch, but we find that it existed in Egypt as early as 1540 B.C. The stone arch is found there, constructed about 600 B.C.

The last rulers of Western Asia, before the advent of Alexander, were the Persians, from 553 B.C. to 333 B.C. These Aryan Persians did not follow their semitic predecessors in all their architectural forms,

but originated a style that is suggestive of the Greek, using the column very largely.

A curious edifice, belonging probably to the later Achæmenian times, is a square tower, composed of large blocks of marble cut with great exactness and joined together without any mortar or cement of any kind. The building is thirty-six feet high and twenty-four feet square. The doorway is not at the bottom, but half way up, and must have been reached by a flight of steps. The most interesting feature, however, from our point of view, is the roof, which consists of four large slabs of stone, reaching entirely across from side to side and measuring about twenty-four feet in length, six feet in width and from eighteen inches to three feet in thickness. The slabs are cut to slope each way from the diagonal lines and were originally clamped together in a very careful manner by iron clamps. This construction is shown in plan by Fig. 7.

I shall pass by Egyptian stone work, not because it is less worthy of notice than that of Western Asia, being, on the contrary, much more remarkable, but because for that very reason it has been more generally discussed, and you are doubtless familiar with its general character. As to the mechanical methods used, however, a few words may be of interest. In blocks of very great length, as the columns at Fateereh, which are about sixty feet long and eight and one-half feet in diameter, certain pieces of stone were left projecting from the sides, like the trunnions of a gun, to which the ropes were attached. The largest of the obelisks, which is at the temple of Karnak, weighs about 297 tons and was brought about 138 miles from the quarry to where it now stands, and those taken to Heliopolis passed over a space of about 800 miles. The method employed was the same as that already described in the case of the colossus. The skill of the Egyptians was not confined to the mere moving of great weights. Their knowledge of mechanism is shown in the erection of the obelisks and in the position of large stones raised to a considerable height and adjusted with the utmost precision; sometimes in places where the space will not admit of the use of the inclined plane. Some of the most remarkable are the lintels and roofing stones of the large temples, the lofty doorway leading into the great hall at Karnak being covered with sandstone blocks forty feet ten inches long and five feet two inches square. In one of the quarries at Syene is a granite obelisk which, having been broken in the centre after it was finished, was left in the exact spot

where it was separated from the rock. From the dimensions of the quarry, and the situation of the stone, it must have been lifted bodily, as was the case also with the other stones taken from the same quarry.

The use of the canal for irrigation, water supply and inland navigation was developed in the East at a very early date. Rain was infrequent, and while there was plenty of water in the rivers, the very existence of the people depended upon their ability to conduct it to their lands. Innumerable mounds, in regions now desolate, show how large a population they sustained. Huge dams were thrown across the Tigris in various places, one of which (the Awai) still remains, seriously impeding the navigation of the river. It is formed of large masses of squared stones united together by iron clamps.

In the tract of land lying between the river Zab and the Tigris near their junction, in which was situated the important town of Calah, a tract which was partly alluvial but more generally of secondary formation, hard gravel, sandstone and conglomerate, are the remains of a canal, undoubtedly Assyrian. The first portion of this canal is tunnel-work, the remainder being open cutting. Its total length is about twenty-five miles.

The great Egyptian canal, from Bubastis (the modern Bebays) on the Nile, to the Gulf of Suez, anticipated the great work of our times —the Suez Canal. The present canal, indeed, follows the course of its ancient predecessor for some distance at the Suez end. Herodotus says it was commenced by Neco (about 610 B.C.), and that it was four days' journey in length, and broad enough to admit two triremes abreast. At the mouth of the canal were sluices by which it could be opened or closed, according to circumstances. Though filled with sand, its direction is still easily traced, running nearly east about thirty-three miles from Bubastis, and then S. S. E. sixty-three miles more to the extremity of the Arabian Gulf. The date assigned by Herodotus for this work is probably much too recent, as monuments of Rameses II. (1350 B.C.) are found on its banks.

Among the most famous feats of ancient military engineering were the canal and bridge of Xerxes. On account of a former disaster to his fleet in rounding Mt. Athos (a stormy promontory resembling our Cape Hatteras in this particular and which Greek sailors still dread to pass), Xerxes determined to cut through the peninsula by a canal twelve furlongs across, the neck of the peninsula being comparatively level. The work was done by the neighboring peoples, each nationality doing

a certain portion. Herodotus, who seems to have been a historian, with considerable engineering sense, says: "The sides fell in continually, as could not but happen, since they made the width no greater at the top than it was required to be at the bottom. The Phœnicians, however, showed their usual skill by making the part assigned to them twice as wide at the top as it was required to be at the bottom." The other work that I have mentioned was a pontoon bridge across the Hellespont from Abydos to Sestos, for the transport of his enormous army. The channel at this point is about one and a half miles broad. A storm having destroyed the first bridge, Xerxes gave orders that the Hellespont should receive three hundred lashes, and that a pair of fetters should be cast into it. Herodotus says that the lashers uttered these words while scourging the Hellespont: "Thou bitter water, thy lord lays on thee this punishment because thou hast wronged him without a cause, having suffered no evil at thy hands; verily, King Xerxes will cross thee whether thou wilt or no. Well dost thou deserve that no man should honor thee with sacrifice, for thou art in truth a treacherous and unsavory river." While this interesting ceremony was in progress, he likewise commanded that the overseers (engineers?) should lose their heads—a fate that should reconcile the engineer of to-day to his lot. The work was finally completed as follows—I quote from the historian again: "They joined together triremes and penteconters, 360 to support the bridge on the side towards the Euxine (Black) Sea, and 314 to sustain the other, placed at right angles to the sea and in the direction of the Hellespont channel, relieving, by these means, the tension of the shore cables. Having joined the vessels, they moored them with anchors of unusual size. * * * * A gap was left in the penteconters in no fewer than three places, to afford passage for passing boats. When all this was done, the cables were made taut on the shore by the help of wooden capstans; this time, instead of using the two materials separately, they assigned to each bridge six cables, two of white flax and four of papyrus. Both cables were of the same size and quality, but the flaxen were the heavier, weighing not less than a talent to the cubit. When the bridge was complete, trunks of trees were sawn into planks and placed side by side upon the tightened cables and fastened upon the top. This done, brushwood was brought and arranged upon the planks, after which earth was brought and heaped upon the brushwood, and the whole trodden down into a solid mass. Lastly a bulwark was set up on

either side of this causeway, of such a height as to prevent the sumpter beasts and the horses from seeing over it and taking fright at the water."

I shall treat very briefly of the Roman works, as these are well known. The Cloaca Maxima or great sewer of Rome, ascribed to the last three kings, *i. e.*, about 520 B.C., is still preserved for a distance of one thousand feet, and still conducts the drainage from the Capitoline and Palatine hills to the Tiber. It is probable that the Etruscans were the designers of this and other early Roman works, as this remarkable nation was already far advanced in civilization when the Romans were ignorant rustics. An arched vault of tufa, with arches of travertine inserted into it at intervals of ten feet, covers the canal, which is about twenty feet wide. The original height was twelve feet, now reduced to from six to seven feet by silting, in spite of frequent cleanings. To prevent inundations or reclaim arable lands, lakes and marshes were drained by works called emissaria. These were either open or covered, and involved, in some instances, a considerable amount of tunnel work.

The drainage of Lacus Fucinas, which was subject to dangerous inundations, was planned by Cæsar but not executed until the time of Claudius (9 B.C.–54 A.D.). The whole basin was laid dry; this being effected by a shaft cut through the solid rock from the lake to the river Levis (now Garigliano), which discharges into the Mediterranean. The tunnel was 15,000 Roman feet in length, 9 feet wide and 14 feet high. Vertical shafts were sunk for the removal of the débris, and inclined shafts for the ascent or descent of the workmen. The solidarity of the Roman Empire allowed the construction of roads that would not have been possible in disconnected Greece. The nature of the ground was almost wholly disregarded as influencing the alignment of the road. Mountains were cut or tunneled, depressions filled, deep valleys or rapid streams spanned by bridges of bold design.

Of tunnels I will mention the so-called Grotto of Posilippo, near Naples, which is still used. It is 2300 feet long by $20\frac{7}{10}$ wide, arched at both ends, with spans of 81 and 84 feet. The material pierced is solid rock.

The Via Appia, below the village of Ariccia, runs for some distance on an embankment faced with freestone, with massive balustrades and seats on both sides. Arched culverts occur at intervals. The roads were either strewn with sand or gravel or paved with solid stones. In

the latter case polygonal stones, usually basalt, were used; the raised footways, when they occur, were generally made of the softer common tufa. The middle of the road was crowned for drainage, as indicated in Fig. 11, which is a cross section of an embankment through the axis of an arched drain. Add rails and cross-ties to this section, and suppose the grade to have been within certain limits, and you will see at once how closely we approach the ancients in one respect and how widely we differ from them in another regard. If we except our iron framing (for they understood wooden framing and reached a point in stone work to which we have never attained), our predecessors originated the constructive forms which we have so greatly extended and use in such a different manner.

XIII.

NOMENCLATURE AND CLASSIFICATION OF MASONRY.

By PROF. L. M. HAUPT, C. E., Member of the Club.

Read April 5th, 1879.

A careful analysis of a large number of masonry specifications has revealed the fact that serious discrepancies exist in the use and meanings of the terms employed to designate the several classes and grades of work, giving rise to misunderstanding between the contracting parties. It is the object of this paper to attempt the removal of these ambiguities by comparing carefully the numerous authorities available, and stating the conclusions obtained in such form as may be readily referred to.

In the preparation and manipulation of stones for building purposes three classes of artisans are employed, viz.: the *quarryman*, the *stone-cutter* and the *mason*. It is the duty of the first to detach the stone from its natural or quarry bed, in a rough state, constituting *rubble*; of the second, to reduce the mass to prescribed dimensions with a specified finish, constituting *cut* or *dressed stone*; and of the third, to lay the stone with its proper bed and bond in the structure, constituting *masonry*.

Hence arise two general classes of masonry—one based upon the preparation of the individual stones, or *the finish*, and the other, upon

the method of laying, or *the bond*. The first of the above classes naturally resolves itself into the subdivisions of CUT OR DRESSED and UNCUT OR ROUGH stones. The second may also be subdivided into masonry, in which the horizontal joints are *continuous* throughout the structure, or REGULAR COURSED; and that in which they are *not continuous*, but broken in offsets, constituting IRREGULAR-COURSED OR RANDOM MASONRY.

In designating masonry, therefore, it is seen that to give a clear idea of the kind intended, not only the *bond* but the *finish* should be distinctly specified, and care should be taken that there be no ambiguity in regard to the ordinary meanings of the terms used.

The terms ashlar and rubble do not appear to be clearly understood, and even the authorities are not in perfect accord on this subject. In a paper read before the American Society of Civil Engineers, November 7th, 1877, by Messrs. Croes, Merrill and Van Winkle, ashlar masonry is defined to be "Equivalent to cut-stone masonry. * * * As a rule the courses are continuous, but sometimes they are broken by the introduction of smaller stones of the same kind, and it is then called *broken ashlar*. * * * From its derivation, ashlar apparently means large, square blocks, but practice seems to have made it synonymous with 'cut-stone,' and this secondary meaning has been retained for convenience." And the same authorities define "cut-stone" to be those which are "squared and have smoothly-dressed beds and joints." Another authority defines ashlar to be composed of "stones dressed and pitched well and properly so that the *face* of each be a polygon of straight sides not to exceed *six* in number." This is called *broken* ashlar; but if ashlar be *squared* stone, as above defined, this class must be excluded; and since it is more than rubble, having the *joints dressed*, it must belong to the genera of "cut-stone;" yet according to the definition given by the committee of the American Society of Civil Engineers the joints should be at right angles or squared, which they are not, hence it is desirable to make a distinction between ashlar and "cut-stone" by omitting the word *squared* from the definition of the latter, and calling the work just described *dressed rubble*. By so doing it is excluded from the species ashlar, yet included in the genera "cut-stone."

It would appear then that definitions based on the relative position and kind of joints would preserve the distinction between the two grand divisions of ashlar and rubble. So long as the stones are

"squared," that is, having beds and vertical joints at right angles to each other, the masonry built of them is *ashlar*, whether the courses be continuous or not. If continuous and of equal height it is "*regular ashlar*," if discontinuous it is "*broken-range*," "*irregular*," or "*random ashlar*." (These three terms are practically synonymous.) If continuous but of unequal height it is simply *range work* or *block-in-course*.

If the stones are *not* "squared" but have hewn joints perpendicular to the face, and making any angles with each other, it is "*dressed rubble*," and if unhewn or in a natural state, simply "*rubble*." The face of "dressed rubble" may be hewn, pitched, or rough.

Ashlar.

Gwilt defines ashlar as "common or freestone, as brought from the quarry—also the facing given to square stones on the front of a building." Webster quotes from Gwilt.

Rankin says, ashlar or hewn stone, consists of blocks cut to regular figures, generally rectangular, and built in courses of an uniform depth, seldom less than one foot.

Burn, in *Working Drawings and Designs*, defines it as a facing of hewn and dressed stone given to walls, the back of which is rubble.

Knight, *American Mechanical Dictionary*, makes two classes: (*a*) *Rough*, a block of freestone as brought from the quarry. (*b*) *Smooth*, a block dressed ready for use.

Parker, in his *Glossary of Architecture*, is most explicit, and says it is hewn or squared stone, used in building, as distinguished from that which is unhewn or rough as it comes from the quarry; it is called by different names at the present day, according to the way in which it is worked and is used for the facings of walls, and set in *regular courses as distinguished from rubble*. * * * He adds: "clene hewen" or finely-worked ashlar is frequently specified in ancient contracts for building, in contradistinction to that which is roughly worked, and quotes from old MSS (1465–6), as follows: "Here folwth the maner and certeyne rule of meatynge of *ashelers*. First it is to understande that every *ashlere* is xij ynche thykke and xviij ynche longe, wiche multiplied togedere make ij. c. xvj. ynches; and so every *asheler* of what lengthe or brede that he be of, conteyneth ij. c. xvj. ynches; and that shall be your devysore ever in meatynge of *ashelers*.

"Eampylle of meatynge affter the gawge of xij meten, in lengthe xviij yerdes, wyche makethe in fete liiij (54); which makethe in ynches vj. c. xlviij. (648), wiche multiplied wythe the gawge makyngeth ynches vij m^{le}. vij. c. lxxvj (7776) wiche devyded be ij. c. xvj (216) makethe of ashelers xxxvj (36)."

From which it appears that the stones were "squared," and that there were 36 of them in a length of 18 yards, or each stone was 18 inches long and 12 inches high, making a face of 216 square inches.

BRANDE and COX define ashlar as being stone reduced to a rectangular form; and

TOMLINSON, as stone squared and dressed to given dimensions.

RUBBLE.

PARKER defines rubble as "stones not large but irregular in size and shape, and not so flat-bedded as in rag work; it is generally used for the backing."

American Encyclopædia, as coarse walling of rough stones.

BRANDE and COX, as any stone broken from the quarry in rough, irregular masses, and not subjected to any further dressing.

TOMLINSON, stones used without being squared.

From the authorities already quoted it is evident that the chief distinction between ashlar and rubble consists in the shape of the stone, the first being squared, the second *not;* and yet we find a reliable authority defining dressed *rubble* as consisting of *squared* stone (not less than 18 inches high, with no bed less than 18 inches or less than the height of the stone). The term is a misnomer, as such masonry should be classed under the generic term ashlar and may be either *range-work*, *random* or *irregular ashlar*, or "*rock-face pitched ashlar*, *etc.*, according to circumstances.

Another authority says "*rubble* will be built of stone at least nine inches thick, and each stone must have one-fourth more bed than rise, and a length not less than twice nor more than four times the rise. The coursing may be irregular." The stones herein described are evidently squared and consequently cannot properly be classed as rubble.

In addition to the laxity existing in the use of terms, another source of trouble arises from the introduction of impossible conditions concerning dimensions. For instance, the specifications for first-class bridge masonry used on an important railroad, read as follows:

"Courses of stone in abutments, piers and walls are to be not less than *ten* nor more than thirty inches thick *Stretchers* to be not less than two and a half nor more than six feet long and not less than one and a half feet wide, nor less in width than one and a fourth times the the depth." This would make the least allowable depth 14·4 inches, whereas above it may be 10 inches. Again, "*headers* must not be less than three and a half feet nor more than four and a half feet long, where the thickness of the wall will admit of the same, and not less than *one and a half feet wide* nor less in width than they are in depth of course. The *joints*, well broken, in no case less than *twelve* inches."

These requirements give as the least width of header $1\frac{1}{2}$ feet, and for lap of joint 12 inches on either side, making two feet more or $3\frac{1}{2}$ feet for least allowable length of stretcher, whereas above it may be but $2\frac{1}{2}$ feet.

Since masonry is also specified as first, second and third-class, it is desirable to prescribe if possible the characteristics of these various classes.

The requirements of FIRST-CLASS MASONRY are found generally to be as follows:

Courses not less than twelve nor more than thirty inches in height.

Stretchers not less than four and a half nor more than six feet long, height equal that of the course, and width one-fourth greater than the height for courses under 16 inches, and where course is greater it should at least be equal to height.

Headers not less than three and a half feet long (unless in a narrow wall); height equal to that of the course, and width equal to height. The headers should occupy from one-fifth to one-third the face of the wall.

Joints should not be more than three-eights of an inch wide, and the vertical joints should be dressed back at least one foot from the face. The beds should be dressed true and out of wind. If the surface be "rock-face" it should be pitched and the projections should seldom exceed four inches, though the limits vary from one to six. It is frequently drafted.

In SECOND-CLASS MASONRY the stones are smaller and need not be laid in continuous courses. It, therefore, includes random, broken-range and irregular ashlar. The joints are not so closely dressed, varying from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch, but should be horizontal and vertical.

THIRD-CLASS MASONRY consists of rubble either dressed or rough, but well scabbled and with close joints well filled with mortar and small stones (chips or spalls). There should be no spaces greater than six inches to be filled with mortar.

Many combinations may be made of bond and finish, as rock-face pitched ashlar, regular-coursed smooth ashlar, regular-coursed polished ashlar, random-coursed toothed ashlar, etc.

There are also other classes of masonry, based upon its use, as arch, culvert, box, etc., to which the preceding remarks may be readily applied.

MASONRY.

A structure of stone or brick-work, laid either dry or with mortar.

CUT OR DRESSED, having at least the joints and beds hewn.			UNCUT OR ROUGH, as blasted from the quarry.	
(*A*) CLASSIFIED ACCORDING TO ***BOND***.				
ASHLAR.			RUBBLE.	
1. REGULAR ASHLAR; squared and laid in horizontal courses of equal heights.	2. RANGE-WORK or BLOCK-IN-COURSE; differs from *regular* only in having courses of less height (7″—9″).	3. IRREGULAR, BROKEN-RANGE or RANDOM; squared stones laid in irregular courses of variable height.	1. COURSED; laid in rough courses, without having joints vertical.	2. ROUGH; laid at random.
(*B*) CLASSIFIED ACCORDING TO ***FINISH***.				
ASHLAR.			RUBBLE.	MISCELLANEOUS.

MISCELLANEOUS.

BETON, CONCRETE; an artificial substance composed of broken stones, bricks, shells or other minerals, of various sizes, mixed with sand, cement and water in various proportions.

RIP-RAP; an apron or revetment of rubble stone loosely thrown into position.

RAG WORK; masonry of small flat spalls of slates or shales laid in mortar.

RUBBLE.

ROUGH; unhewn stone as taken from quarry.

DRESSED; having the joints wrought to a plane surface, but not "squared."

ASHLAR.

AXED; dressed to a plane surface with an axe.

BASTARD; a term sometimes applied to combination walls, the face being ashlar; back, rubble.

BOASTED or CHISELED; having face wrought with a chisel or narrow tool.

BROACHED; dressed with a "punch" after being droved.

BROKEN; six-sided (improperly used. See dressed rubble).

BUSH-HAMMERED; dressed with a bush hammer.

CRANDALLED; wrought to a plane with a crandall.

DIAMOND work; that in which the face is formed by four planes meeting at the intersection of the diagonals.

DRESSED work; that which is wrought on the face.

DRAFTED; having a narrow chisel draft cut around the face or margin.

DROVED, STROKED; wrought with a broad chisel or hammer in parallel flutings across the stone from end to end.

HAMMER-DRESSED; worked with the hammer.

HERRING-BONE; dressed in angular flutings.

NIGGED, NIDGED; picked with a pointed hammer or cavil to the desired form.

PATENT-HAMMERED; dressed with a patent hammer.

PICKED; reduced to an approximate plane with a pick.

PITCHED; dressed to the neat lines or edges with a pitching chisel.

PLAIN; rubbed smooth to remove tool marks.

POINTED; dressed with a point or very narrow tool.

POLISHED; rubbed down to a reflecting surface.

PRISON; having surface wrought into holes.

RANDOM-TOOLED or Droved; cut with a broad tool into irregular flutings.

ROCK-FACED, QUARRY-FACED, ROUGH; left as it comes from quarry. It may be drafted or pitched to reduce projecting face to given limits.

RUBBED; see plain.

RUSTIC, RUSTICATED; having the faces of stones projecting beyond the arrises, which are beveled or drafted. The face may be dressed in any desired manner.

SMOOTH; see plain.

SQUARE-DROVED; having the flutings perpendicular to lower edge of stone.

STRIPED; wrought into parallel grooves with a point or punch.

STROKED; see droved

TOOLED; wrought to a plane with an inch tool (see droved).

TOOTHED; dressed with the tooth chisel.

VERMICULATED, WORM WORK; wrought into veins by cutting away portions of face.

XIV.

PROPER AMOUNT OF WATER-WAY FOR CULVERTS.

By Thos. M. Cleemann, A.M., C.E., Member of the Club.

Read April 5th, 1879.

It is desired to call the attention of the Club this evening to a subject which often presents itself to the engineer in constructing railroads, and to request that the paper will be freely discussed and unsparingly criticised; and the writer will be abundantly satisfied if facts are produced bearing on it, whether they sustain or disprove.

It often happens, in designing the culverts for a new railroad, that there is great uncertainty in regard to the proper opening to give them. The oldest inhabitant of the neighborhood is sought for and his experience appealed to as to the height of the greatest flood in his recollection, and the engineer soon learns that he had better add to the old man's testimony a considerable amount, if he wants the culvert to safely pass the water. After a road is built, floods often occur greater than any previously known. There seems, indeed, but little doubt that the cutting off of the forests has increased the floods over what they were formerly, even though the annual rain-fall may be the same.

A formula is now offered which has been communicated by a distinguished engineer of Richmond, Virginia, Major E. T. D. Myers. He has discovered it, and finds it to apply well to the water-courses he has been able to examine, which lie generally on the line of the Richmond, Fredericksburg and Potomac Railroad. It is as follows:

$$A = c\sqrt{M}$$

where A is the area of the opening of the culvert in square feet, M is the drainage area in acres, and c is a variable co-efficient, depending on the country, and which he states is, in hilly, compact ground, equal to $1\frac{6}{10}$, and in comparatively flat ground, equal to 1.

The relation between the drainage area and the amount of water flowing in the greatest flood has been stated in approximate formulas by several writers, as mentioned in Fanning's "Treatise on Water-supply Engineering." He gives his own formula:

$$Q = 200\,(M)^{\frac{5}{6}}$$

also, one of Col. Dickens:

$$Q = c \times 27\ (M)^{\frac{1}{2}}$$

and one of Mr. Dredge:

$$Q = 1300\ \frac{M}{L^{\frac{2}{3}}}$$

in which Q is the volume of discharge in cubic feet per second, M is the area of water-shed in square miles, L is the length of water-shed in miles, and c is a coefficient, to which Col. Dickens gives a mean value of $8\frac{1}{4}$ for East Indian practice, but to which a value of 50 agrees better with the discharge of the rivers mentioned below. These are all intended for much larger streams than Major Myers intends his own formula to be applied to. However, theoretically, the same elements are concerned in both cases, and a common formula should express them.

Let us first compare these several formulæ with some actual rivers. In a late number of the *Engineering News*, in a report of Messrs. Cross and Howell on the water supply of Newark, the drainage area and the greatest flood of the Passaic River are given. In Generals Humphreys and Abbot's report on the Mississippi River, the same quantities are given for that river at Columbus and for the Ohio at Wheeling. The result of a comparison of these data is as follows:

River.	Drainage area.	Maximum flow cubic feet per second.	Fanning, $Q = 200\ (M)^{\frac{5}{6}}$	Dickens, with adapted constant, $Q = 50 \times 27 \sqrt{M}$	Dredge, $Q = 1300\ \frac{M}{L^{\frac{2}{3}}}$	Length of water-shed in miles.
Passaic, ...	200	18,000	16,540	19,092	19,160	50
Ohio at Wheeling, .	23,000	200,000	862,000	204,728	569,524	380
Mississippi at Columbus,	901,000	1,403,000	18,340,000	1,281,434	5,499,065	3120

It is seen that the formula of Col. Dickens gives the nearest approach to accuracy. The formula of Mr. Dredge contains the length of the stream, and abstract considerations would seem to point to this as being more correct. However, the above comparison seems to indicate that the function is not in the proper form in the formula.

Col. Dickens' formula bears great resemblance to Major Myers', except that it gives the quantity of water discharged, while the latter gives only the size of the opening through which it should pass. To make the two comparable, the latter must be multiplied by an assumed velocity. This we shall take as that at which pebbles about one inch in diameter are just moved—according to Trautwine's Pocket-book—2 feet per second at the bottom, or $2\frac{1}{2}$ feet for the mean velocity. We then have, reducing the M in acres to M in square miles, and taking the value of the coefficient at $1\frac{6}{10}$,

for Col. Dickens' formula, $Q = 50 \times 27 \sqrt{M}$

and for Major Myers' formula, $Q = 3\frac{3}{4} \times 27 \sqrt{M}$

We may therefore conclude that, for calculating the discharge of a stream, the formula of Col. Dickens may be used, giving c a value of $3\frac{3}{4}$ for small streams, of $8\frac{1}{4}$ for larger streams and of 50 for very large rivers. However, the form of Major Myers' formula is better for adaptation to the ordinary wants of engineers, and it is, therefore, recommended to their attention.

It is worthy of remark that there sometimes occur storms of so violent a character that it would appear as though no culvert were wide enough to pass the water. Such a one was that which occurred a year or two ago on the Pickering Valley Branch of the Reading Railroad, when something like a water-spout seemed to have moved in a straight line from near Lambertville (?) to Penningtonville, and washed out the culverts on the railroads that it crossed. Mr. Trautwine examined the place where it struck the Pickering Valley Branch, and says that the thickness of the railroad embankment was much greater than what would have held water in a reservoir of a greater depth, and yet it was entirely swept away, leaving the culvert, however, uninjured. For such exceptional cases, which lawyers call "the act of God," no formula can be framed, and one would, indeed, be of no use. Their rarity fortunately renders it unnecessary to attempt to provide for them.

Before closing, it is requested that any gentleman who is connected with a railroad will make some measurement of the greatest floods passing through some of his culverts, even if it is only the greatest depth of the water multiplied by the width of water-way. It would add to the value of the observation if the velocity at the time were also noted. The drainage area could be measured from county maps, and the dis-

cussion of the observations would be a labor of love to the writer, and, he ventures to think, would likewise be of service to his professional brethren.

DISCUSSION: By CHAS. G. DARRACH, D. McN. STAUFFER and RUDOLPH HERING.

MR. CHAS. G. DARRACH said that several years ago he had charge of the construction of a railroad which followed a ravine, between hills rising on each side to a height of several hundred feet, near Columbia, Pennsylvania. At one place the road crossed a lateral valley, over which an embankment was built, which was about twenty feet above a small stream, which flowed through it. The drainage area of this stream was 215 acres, and a double box culvert was put in to carry the water, each opening of which was three by four feet. This water-way would agree almost exactly with what Major Myers' formula requires, using his larger coefficient. A great storm, however, occurred shortly after it was completed, when the water accumulated much more rapidly behind the bank than the culvert carried it off, until in about two hours' time it overtopped it, and swept it away. The cubic contents of the water dammed up by the bank was about 4,000,000 cubic feet. To carry this water off in one and a half hours, the duration of the storm, with a head of nine feet, about the average head until it topped the bank, requires an opening of about $\frac{4,000,000}{103,680} = 38$ square feet additional. To meet this case, therefore, the coefficient in Major Myers' formula should be raised to 4·2. Such a storm, however, as is here spoken of, only occurs in the mountains, in this part of the country; a bucket which was standing in an exposed place during the storm, alone, so that it could have received water from no other source than rain, and which was eight inches deep, was filled to overflowing in the short space of an hour and a half, which indicates an unprecedented rainfall for the locality.

MR. D. McN. STAUFFER remarked that on the Lower Mississippi he had observed rains when standing at one end of a vessel, he could see nothing at the other end, only 175 feet off, the rain pouring down in the intermediate space in such great quantity that everything was obscured at that distance. It is probable that such a storm would require a still further increase of the coefficient.

Mr. Rudolph Hering read the following:

The subject of Mr. Cleemann's paper is certainly one of great importance, as railroad accidents caused by failing culverts frequently testify; it may, therefore, not be out of place to enter into it a little further. Having lately jotted down some notes on the same subject, I will present them in connection with his paper, because they show, as I believe, for reasons given further on, that Major Myers' very convenient formula should be used only under quite similar conditions to those from which it was deduced, and that it might be unsafe when otherwise applied. With many others, it belongs to a class of formulæ which, being derived from comparatively few observations within a limited range, are yet recommended for general use. The subject of hydraulics particularly abounds with such, and many a disastrous consequence has been traced back to the use of one, which being developed under certain conditions, was applied under very different ones.

For instance, take Eytelwein's formula for the mean velocity in a stream of water, which has been extensively used. It applies with tolerable accuracy to small rivers with light grades and irregular beds, canals in tolerably good order, and was also found to give reliable results for small and smooth artificial channels and pipes with heavy grades. Using it, however, as has been done with disastrous results, for a small channel with a light grade, very carefully excavated in earth, we will find the actual velocity to be so much in excess of the one given by the formula that it may completely destroy the channel. Or, using it for old pipes, or small channels with very rough perimeters, especially when the grade is light, we may only get one-half the amount of water as calculated according to Eytelwein.

We should, therefore, be aware that, although the inductions from a series of experiments made under slightly varying conditions are perfectly trustworthy within these limits, yet they do not necessarily hold good beyond them, and such formulæ, with a limited application, should be given to the practical engineer, only, if the conditions under which they were developed and the *limits* of the values which may be substituted in them are likewise given, as an inherent part, being of as much value as the formula itself. This I take to be of great importance, because when we see an equation, a mathematical expression, it naturally has an appearance of exactness and imparts confidence, and will likely be used for all cases where values, whatever they may be, can be substituted.

The very simple and convenient formula which Mr. Cleemann has recommended to us contains the sectional area of the culvert, the drainage area and a coefficient for which two values are given, one applying to flat, the other to hilly countries. That is all—no other quantities are mentioned. Yet, will any one for a moment doubt that the sectional area of the culvert *varies directly* as the mean velocity of the water passing through it? Further, no one will deny the importance of considering the maximum rainfall of the district, which is very different, even in sections of our own country; and lastly, it is evident that the amount of water flowing off the drainage area will be greatly affected by its topographical and geological features.

Therefore, unless we have more detailed information as to the conditions under which Major Myers found his formula correct, it should be used only with the greatest caution, knowing that we are neglecting some essential factors.

The importance of determining the proper size of water-way for culverts or small bridge openings, especially in cultivated districts, justifies the engineer, I believe, in entering further into the subject and not being content with a formula like the one under discussion. Hydraulic science gives us the means of ascertaining other factors with at least an approach to a reasonable degree of accuracy, and ought we not to take a little trouble to carefully ascertain the main dimensions of our public works, rather than to use a formula which saves a little time but which may contain an important omission or an error in disguise? Indeed, considering the pay that engineers usually receive for their time, it is economy badly misplaced.

Let us see what can be done towards solving the problem more rationally.

The determination of the maximum amount of flood water discharged at the point where the culvert is to be built will be the most important item. If we designate this amount passing per second by Q, the duration of the rainfall by t, the mean velocity with which the water flows down the valley before reaching the culvert by v, and the depth of rainfall which actually runs off a strip of ground, per second, by d, the width being unity, then

$$Q = tdv \qquad (1)$$

Further, if t_1 is the time in which the water falling near the periphery of the drainage area reaches the culvert with the velocity v, and l is the average distance which this water travels, then

$$t = vt_1, \text{ or } v = \frac{t}{t_1} \tag{2}$$

Substituted in equation (1), we get

$$Q = \frac{tdl}{t_1} \tag{3}$$

Applying this to the whole area, designated by M, and, as td is the entire depth of rain flowing off during the storm, substituting the letter D, we get

$$Q = \frac{DM}{t_1} \tag{4}$$

which shows that the discharge depends on the depth of rainfall running off the area and the time in which the water falling at its periphery reaches the culvert.

[Equation (4) may also be used in the form

$$Q = \frac{DMv}{L} \tag{4 a}$$

if L denotes the length of the river and v its mean velocity. In this form it is very similar to the formula of Mr. Dredge, who recognized the importance of the *length* of the river. He derived it from observations at twenty-seven bridges in India, of above eighty feet span, and assumes a maximum rainfall of six inches in twelve hours.]

The maximum discharge per second occurs when $t = t_1$, *i. e.*, when the shower continues at least as long as it takes the water from the water-shed line to reach the culvert. This substituted in equation (3) and applied to the entire area, gives

$$Q = Md \tag{5}$$

Should the rain continue still longer, *i.e.* t be greater than t_1, the *amount of discharge*, however, cannot increase; therefore, equation (4) or (4 a) is applicable when $t < t_1$, or for large areas, and equation (5) is applicable when $t \overline{\overline{>}} t_1$, or for small areas. The former, then, applies to all rivers, where the knowledge of the factor t_1 is all-important. The larger the river the longer the time t_1 will be. We never get the maximum flood discharge *before* the rain has ceased, but in the largest rivers as much as *several days thereafter*. The important difference between this case and that of small areas, where t_1 is not considered, is apparent.

Major Myers, as we understand, confines his formula to *culverts*. Therefore we must compare it with equation (5), although Mr.

Cleemann believes that there should be a common formula for both cases, and compares it accordingly with observations on large rivers.

If satisfactory values for the factors *M* and *d* can be substituted in equation (5), then it must give the maximum flood discharge with tolerable accuracy. It is the formula used in cities for the proportioning of sewers, and in some parts of Europe it is the regulation formula for designing culverts under railroads and roads. Let us see what can be expected of it.

As *M*, the drainage area, is desired in both this and Major Myers' formula, it needs no further notice. *d*, the depth of rainfall actually running off the ground per second, depends on the season, the section of the country, the geological and topographical features of the ground. The many observations made in every civilized country of the amount of rainfall in various localities enables us to determine directly or indirectly the probable maximum rainfall within limits which are close enough for our purpose. Mr. J. B. Francis, one of our most eminent hydraulic engineers, compiled a table from an extensive series of observations of the great storm of October, 1869, in the eastern part of the United States, which I will give here, as this storm has been considered a fair maximum to provide for.[1]

6″	or more of	rain	fell over	24,431	sq. miles.
7″	"	"	"	9,602	"
8″	"	"	"	1,824	"
9″	"	"	"	1,046	"
10″	"	"	"	519	"
11″	"	"	"	179	"

The storm lasted about 30 hours, but about one-half the total quantity is reported by several observers as having fallen on the second day (when the ground was already well saturated), within two or three hours. In Washington four inches have been recorded as falling in two hours; in Philadelphia and New York, two inches in one hour.

The proportion of the rainfall that is evaporated, absorbed by the soil and retained in the forests and vegetation is more difficult to obtain, as it depends on local causes and varies enormously with them. Should it be said that the general coefficient of Major Myers includes the effects of these influences, then it will be seen at once that the respective formula is only applicable at those localities where it was tested.

[1] Trans. Am. Society of Civil Engineers, August, 1878.

Observations have been occasionally made to facilitate our judgment as to what amount will run off. It is found that in summer the evaporation and absorption for small areas amount to from 30 to 75 per cent. of the entire rainfall, the latter especially, when the showers are short. In the winter and spring months, when the ground is frozen and covered with snow, the absorption and evaporation are very slight. In the Alps the mountain streams rise and fall with the *temperature* almost in a direct proportion, on account of being mainly fed by melted snow.

From various records we find that about 10 to 50 per cent. of the summer and fall rains, or 50 to 100 per cent. of the winter and spring rains, including the melted snow, may immediately run into the creeks, depending on the temperature, the rainfall itself, the nature of the soil, whether clay, sand or rock, the amount and character of the vegetation, and on the general slope of the drainage area. But even these limits may be exceeded when the circumstances are particularly favorable, and it will depend on the experience and judgment of the engineer to select a proper value for d.[1]

Although a close approximation is all that can be expected at best, this estimate, if the engineer is at all competent, will at least be intelligent, and a great error cannot be made. And he will never be relieved of exercising this judgment to some extent, for it is impossible to bring geological features and the density of vegetation directly into a mathematical form. It must always remain necessary to judge of the particular coefficient representing certain physical features.

The probable maximum discharge, then, is obtained from the area, and from the depth of rainfall flowing off, which can be estimated by any skillful engineer from records and observations within a degree of accuracy answering all ordinary purposes.

Another approximation of the maximum discharge can be obtained independently of the rainfall and area, should a flood-mark be found somewhere in the valley near the site of the culvert, by measuring the area of water-way at that point and finding the grade as near as possible, in order to calculate the mean velocity.

Having determined the probable flood discharge to be provided for in constructing the culvert, its dimensions are easily obtained as follows:

[1] In the closely built-up sections of our Eastern cities one-half to three-quarters of the maximum fall is estimated to immediately reach the sewers; in the suburban districts from one-quarter to one-half.

If x is the width and y the height to which the water may rise, and v the permissible velocity of the water flowing through the culvert, then

$$x\,y = \frac{M\,d}{v} \tag{6}$$

the values to be substituted being in feet and seconds; but the formula is nearly correct as it stands, if M is given in acres, d in inches per hour and v in feet per second; x and y are in feet.

Comparing this formula with that of Maj. Myers, we find that his coefficient has a value of

$$c = \frac{d\,\sqrt{M}}{v} \tag{7}$$

therefore is really dependent on three variables, and for which only two values are specified, namely, for flat countries $c = 1$ and for hilly countries $c = 1{\cdot}6$, which are said to apply well to the water-courses on the line of the Richmond, Fredericksburg and Potomac Railroad. If, in addition, we had the values of M, d and v of the cases where this formula was found to answer, we would be able to use it intelligently.

In order to compare the results of the formulæ better, the following table was prepared, which needs but little comment.

Fanning's formula, which is derived from data collected in the New England and Middle States, has been added. The values for the velocities and depths of rain flowing off are selected within entirely reasonable limits. That one inch of rain flowing off from 6400 acres or 10 square miles is not unreasonable, may be seen by examining Mr. Francis' table. Unfortunately, I have not been able to obtain any observed value of d for that storm. One-half an inch has, however, been recorded as running off from 11 square miles, which would require Maj. Myers' coefficient c, with a favorable comparison, to be 16, or, ten times greater.

We can readily see from the table when Maj. Myers' formula would answer and when not, that generally it would not be sufficiently safe for the larger areas, and that certainly a much larger coefficient would be necessary for our conditions and those of New England, which confirms the remarks of Mr. Darrach and Mr. Stauffer.

	$xy = c\sqrt{M}$ (Myers).		$xy = \frac{0{\cdot}917M^{\frac{3}{4}}}{v}$ (Fanning).			$Q = Md;\ xy = \frac{Md}{v}$			
M Area. Acres.	c Coefficient. Two constants.	xy Water-way. Square feet.	Q Flood discharge. Cu. ft. per second.	v Velocity in Culvert. Feet per second.	xy Water-way. Square feet.	d Depth of rain flowing off. Ins. per hr.	Q Flood discharge. Cu. ft. per second.	v Velocity in Culvert. Feet per second.	xy Water-way. Square feet.
1	1·6	**1·6**	·92	2	**0·46**	2	2	2	**1·0**
	1	**1**		5	**0·18**			5	**0·4**
						1	1	2	**0·5**
								5	**0·2**
25	1·6	**8**	13·4	2	**6·7**	2	50	2	**25·0**
	1	**5**		5	**2·7**			5	**10·0**
						0.5	12·5	2	**6·3**
								5	**2·5**
100	1·6	**16**	42·6	2	**21·3**	1	100	2	**50**
	1	**10**		5	**8·5**			5	**20**
						0·2	20	2	**10**
								5	**4**
2500	1·6	**80**	622	2	**311**	1	2500	2	**1250**
	1	**50**		5	**125**			5	**500**
						0·1	250	2	**125**
								5	**50**
6400	1·6	**128**	1363	2	**682**	1	6400	2	**3200**
	1	**80**		5	**273**			5	**1280**
						0·1	640	2	**320**
								5	**128**

In addition to what has been said, several points which will modify the results yet remain to be mentioned.

The calculated height of the water-way should not be above the height of the flood water in the valley, for, in order to discharge the maximum amount, the whole section must be filled and the water would, therefore, have to rise to the calculated line before it could find

full discharge, which might cause flooding over valuable lands or endanger the stability of the embankment or culvert itself. Therefore, this flood height should be ascertained or estimated, and considered as the height of the section which determines y in equation (6). The width of the culvert is, then, the only quantity that should be sought by the formula.

If it is not considered objectionable to raise the flood height in the valley, then it may be advisable to give the culvert a steeper grade which will increase the velocity and, therefore, reduce the size. It will be necessary in all cases, however, to limit the bottom velocity in order to prevent any washing, unless for the sake of reducing the size, it may be economical to artificially prepare the bottom accordingly.

Whenever the velocity of the water approaching the culvert is less than the velocity flowing through it, we must be aware that the latter can not yet be attained at the end section of the culvert. On account of the contraction of the stream, resulting from this gradual change of velocity, the area at the entrance should strictly be increased as the velocity decreases. Where this question is to be considered the wing-walls should be placed, in plan, so as to begin flush with the sides of the culvert and gradually widen out, but not more than just to compensate for the change of velocity. This is frequently done in Europe. The nose of bridge piers is most properly designed in the shape of the vena contracta, and the peculiar beveling of the intrados edge at the haunch of arched bridges, increasing towards the pier, as we find it in France especially, has its æsthetical justification for the same cause.

It will, of course, depend entirely on the least degree of accuracy with which the factors in this whole matter can be obtained, as to how far into the finer considerations it will be reasonable to enter. In most cases very rough approximations will have to do; but where population is comparatively large, land and public works are valuable, the engineer should study closer into the proper proportions of his works, for he ought neither to waste money by making the structures too large, nor cause great risks by having them too small.

XV.

THE CONNECTING ROD.

By JAMES CHRISTIE, Mech. Eng. Corresponding Member of the Club.

Read April 19th, 1879.

In a recent work by Prof. Marks on the Steam Engine—on the subject of connecting rods—we are given rules for calculating the proper diameter of this member, to resist the strains to which it is subjected, and, in a foot-note, are told that experiment does not show any increase of strength by swelling the rod in the middle, and are to infer that a uniform diameter throughout is proper. It is to be presumed that this statement is based on experiments on pillars, regarding which our knowledge is very incomplete, especially on long, solid pillars, whose ratio of diameter to length bears some resemblance to the average connecting rod. Now the experiments of Hodgkinson do show such increase of strength to the extent of 12 to 15 per cent. by swelling the middle of solid round-ended columns, and such advantage would seem reasonable from an examination of the theory of flexure of such columns, where the point of greatest flexure, as in a solid beam, will be found in the middle of the length. The practice of our most eminent mechanical engineers has been to make the crank-end neck of the rod greater than the crosshead-end neck and the cross-section at middle of rod greater than either. In fact, in extremely long rods, trussing of the rod in the plane of its vibration has been advantageously resorted to, the member being thus stiffened in its mid-length at the expense of an increase in the longitudinal compression. The writer believes this practice to be correct, to be in accordance with theory and found a necessity in practice, and will give his reasons for this belief.

A connecting rod under compression acts as a strut, with round ends in one direction—in the plane of its vibration—and square ends in the other direction. For a uniform circular cross-section, it would, therefore, be about three times stronger in the latter than in the former direction, and the practice of those constructors, who make their rods of a rectangular section wider in the plane of vibration than the thickness in the other direction, is correct.

But compression is not the only strain acting at one time on the rod.

It is subject to very peculiar bending strains, which are irregular, shifting, and whose combined effect is to produce tremors in the body of the rod. A rod may be so weak in the body that these tremors, while not causing actual destruction, may impair its efficiency and cause abnormal wear at its connections.

The strains to which many parts of machinery are subjected are so varied, and liable to simultaneous action in different directions that their proper summation has always been a difficult task to the engineer, and we find the deductions of eminent analysts, not only conflicting but even unwarranted, considering our present limited knowledge of molecular resistances to compound strains. As an example of the difficulty of obtaining precise results, let us observe the various forces acting simultaneously or in rapid continuity through the connecting rod.

The initial compression is slightly increased at mid-stroke (usually about 5 per cent.) owing to the deviation of the rod from the direct line of thrust, and again at end of stroke, due to the retarded velocity of the reciprocating parts. As at the latter point the steam pressure is usually much reduced, the effect of acceleration can be disregarded. During the above period, the rod is subject to bending strains; first in one direction, due to resistance to increase of velocity from the beginning to middle of stroke, and then in the other direction, due to retarded velocity from mid-stroke to the end of stroke. Simultaneously there is a continuous bending action, caused by the friction of the crank-pin on its bearings, and an irregular, variable bending strain, caused by friction at crosshead-pin. As all these bending forces act in the plane of the vibration of the rod, they call for swelling or widening of the rod, nearer the crank than the crosshead-end, a slight increase at crosshead-end neck, and a material increase at crank-end neck over and above the proportions required to resist compression alone.

The maximum bending moments due to acceleration, will be found about one-third of the length from crank-end, and the maximum bending moment due to friction, at the neck next crank. The effects of the friction at the connections on the rod are very peculiar and worthy of study by those who desire to obtain a clear knowledge of the subject. The writer has no knowledge of any analysis of the strains exercised by this friction, and it is the purpose of this paper to avoid any tedious equations, using only general and approximate terms.

Starting at beginning of stroke with rod in compression, and sup-

posing that crank and crosshead pins are of same diameter and having equal friction, the friction of the two pins would produce a bending action on the rods in opposite directions. In a rod of uniform section the tendency of this couple would be to give a double curve to the rod, having a point of contrary flexure at the middle of its length, and two points of greatest flexure about one-fourth of the length from each end. As the piston advances in its stroke, these points of flexure shift, until at mid-stroke the point of contrary flexure vanishes at the cross-head-end, as the friction has ceased at that end, the friction at crank-pin only acting, would produce a point of greatest flexure very near that end, and which in practice we can consider concentrated in its action on the crank-end neck of rod. From mid-stroke to the end, the friction of both pins act on the rod in the same direction, tending to produce a single curve, which at the end of stroke would be uniform, with point of greatest flexure at the middle of the rod.

No doubt the tremors in connecting rod bodies, which are very violent in long, weak rods, are not so much due to the alternate tension and compression as to the shifting, irregular undulations, caused, as stated above, by pin friction and by acceleration. That these strains are not insignificant under the high pressures and speeds which is the rule rather than the exception nowadays, let us take as an illustration a 32 by 48 inch engine, making eighty revolutions per minute, under an initial pressure of seventy pounds per square inch, an instance that is within the daily experience of the writer, and assuming the friction at one-twentieth of pressure, length of rod at 10 feet, weight at 1000 pounds, crank-pin 6 inches diameter, simultaneous with the direct compression of 56,000 pounds, there would occur twice during the stroke a maximum bending moment of 2700 ft.-pounds due to acceleration, and at mid-stroke a bending moment of 630 ft.-pounds at the crank-end neck due to crank-pin friction. To summarize the joint action of these bending and compressive strains, we can only take the rules given by Rankine, Weisbach and others ; but, as before stated, we have no experimental knowledge regarding their actual effect.

They demand a rod swelled in the middle, or widened from a point rather nearer the crank than the middle of rod, and the neck next crank larger than the opposite neck, agreeing with the general proportions cited previously. As a comparison between the strength of piston rods and connecting rods, the writer gives below two cases of bending of piston rods, due to impact on water between piston and rear cylinder

head, the reaction, of course, passing equally through the connecting rods, which remained unimpaired. The bend was very slight; the rods being straightened, a cut turned off their diameter and replaced.

Engine 13 cylinder, 36 inch stroke, piston rod $2\frac{7}{16}$ diameter, both necks of connecting rod $2\frac{1}{2}$ inches diameter, swell at middle of rod $3\frac{1}{2}$ inches diameter, length of rod $7\frac{1}{2}$ feet.

Engine 19 inch cylinder, 48 inch stroke, piston rod 3 inches diameter, both necks of connecting rod $2\frac{3}{4}$ diameter, swell $4\frac{1}{8}$ inches diameter, length = 10 feet, all of wrought iron.

The latter engine is severely taxed making 60 revolutions per minute under initial pressure of 70 pounds per square inch. The work is very severe, driving a rolling mill producing large sections and long bars. It will be observed that both necks of latter connecting rod are smaller than the piston rod. Owing to our large factors of safety, the failure of parts of engines, under their normal strains, is very rare. The above-mentioned instances are isolated ones and not conclusive, but the question might be raised: could not solid columns be much reduced at points contiguous to their bases without injury, providing the ends are well supported, as they are necessarily at the stub-end of the connecting rod, which points would be the most likely to fail in a square-ended strut.

All mechanical engineers are indebted to Professor Marks for his very valuable contribution to their literature; for though mechanical engineers always have been, and will be, governed more by precedent than calculation in the designing of steam engines, yet they are continually called upon to design machinery for which there is no precedent, and for the student, his surest foundation is exact knowledge of principles, as a preliminary to practice.

The ultimate compressive resistance of wrought iron, 31,000 pounds per square inch, used by Professor Marks in his numerous examples, is much too low, and tends to mislead; why the early experimenters obtained such results it is difficult to say, but modern experiments on our own metals give nearer an average of 50,000 pounds, and a basis of 45,000 pounds will be safely within a proper limit, with an elastic limit of 25,000 pounds, and average modulus of compressive elasticity 25,000,000 pounds.

The factor of safety proposed, viz.: 10, may seem high to those unaccustomed to proportion the moving parts of machinery in harmony with applied strains. But if we accept the conclusions of Wohler and

others in the case of rapid reversion of strains, to which many p of machinery are subjected, then the sum, and not the greatest alon the alternate strains, is the measure of durability. This would resolved, in referring to the reciprocating parts of engines, to an act factor of 5 instead of the nominal factor of 10; where extra str and stiff machinery is required this factor will be found too low.

The writer has found good results from the following factors machines of ordinary strength. When loads are continuously evenly applied, 5; when impulsively or suddenly applied, 8; when suddenly reversed in direction, 10.

XVI.

THE WATER SUPPLY OF PHILADELPHIA.

By CHAS. G. DARRACH, C.E., Member of the Club.

Read May 3d, 1879.

This subject, although hackneyed, is still a fruitful source for thou From the time of Franklin to the present it has been discussed many able engineers, which makes the writer crave your indulge ask you to bear patiently with his remarks and criticise without rese his suggestions.

The two means for a water supply are pumping and gravity. the present case, that of our own city, pumping is the cheapest, the only reason for suggesting a gravity supply is the fear of the c tamination of our rivers.

The Schuylkill river, of world-wide fame as a source of pota water, would be all that could be wished were it not for the *sewag* the city itself and that of the other cities and towns upon its tributa

The protection of the water-courses should be made the subject wise legislation, and engineers should be taught that a system of sew age admissible on the seaboard is not only unwise but criminal w applied inland. When the large streams and rivers are conve into sewers, where will we find locations of protected drainage storage for those cities whose suicidal policy has destroyed their nat source of water supply?

This question is one which presents itself even now to the hydra engineer, and year by year becomes more difficult. If the Schuyl

[w]as protected from the sewage of the cities on it and Philadelphia [p]rovided with a system of intercepting sewers, the thought of a gravity [su]pply would not for a moment be entertained, involving as it does [th]e contemplated expenditure of millions, as well as the destruction of [e]xpensive works which now pay a revenue of a million and a half of [m]oney—about three hundred per cent. of their total running expenses [fo]r maintenance of the Department.

We are, however, by no means certain that such legislation and protection can be obtained, and it becomes an all-important question, in the present expenditure of money and in the designing of new works, that they shall be in harmony with any plan that may in the future be adopted.

Gravity as a means of supply was first suggested from the Wissahickon by Franklin, which, had the project been adopted, would have been sufficient in quantity until the last few years. From time to time different suggestions have been made, and the various small streams in the vicinity, as well as the Delaware river, have in turn had their champions. Among others, it has been suggested to bring the waters of the Delaware by gravity, in a conduit 100 miles long, from the Water Gap—in an air-line 70 miles distant. This is the best of the Delaware-river schemes, since one plan, making New Hope the initial point, and the other Yardleyville, both require pumping—the last by steam power at the city, the other by water power at New Hope.[1]

The most feasible plan was suggested by Mr. Birkinbine in 1865, but it has not been developed either as to the actual location of the conduit line or to the adaptation of the distribution to the city supply.

In 1865, under the direction of Mr. Birkinbine, the drainage areas of all the available streams were determined, their merits discussed and preliminary surveys for the proposed collecting and storage lake and the conduit line were made. The commission of experts appointed by the Mayor in 1875 examined the subject, directed preliminary surveys, and Mr. Wm. J. McAlpine, one of their number, submitted estimates for the completion of the work, comparison of cost, probable

[1] The surface of the Delaware river at the Water Gap is . 289 city datum.
At New Hope, ... 40 "
At Yardleyville, ... 10 "

size of conduit and the required storage to tide over the months of least rain-fall and maximum demand.

Since this report other data have been collected upon which we can base a closer estimate of the supply which may be obtained and how it can be distributed.

The Demand.

The amount required for the future supply was determined by the experts to be 200,000,000 of gallons per day for the entire year. The present daily average for the year is 55,000,000 of gallons, and for the month of July 66,000,000. Quoting from the report of the Chief Engineer of the Water Department for 1876, we find that "from 1810 to 1849 the pumpage increased at the rate of 43,600,000 gallons per annum, and from 1849 to 1876 at the rate of 540,000,000 gallons, or more than twelve times as much. In the eight years from 1854 (the year of consolidation) to 1862 the pumpage doubled. The pumpage will again double in 1878, or in 16 years, and by their ratio after 1878, in 32 years, or in 1910," continuing this ratio in 64 years, or in 1974.

In 1854	the daily average	was about	12,000,000
" 1862	"	"	22,000,000
" 1878	"	"	52,000,000
" 1910	"	will be	104,000,000
" 1974	"	"	208,000,000

The following table, taken from the actual experience of 1878, gives the ratio of monthly consumption :

January,	85	per cent. of	the daily average	of the year.
Feb.,	76	"	"	"
March,	90	"	"	"
April,	101	"	"	"
May,	105	"	"	"
June,	108	"	"	"
July,	120	"	"	"
August,	109	"	"	"
Sept.,	112	"	"	"
Oct.,	106	"	"	"
Nov.,	95	"	"	"
Dec.,	93	"	"	"

The Supply by Gravity.

The table prepared by Mr. McAlpine to determine the required storage in the collecting lake was based upon a rain-fall one-fifth greater than that of 1858 in Philadelphia, whereas the rain-fall at Philadelphia, Reading and Lebanon for 1878 compares with it as follows:

	Phila.,[1] 1858.	Phila., 1878.	Reading, 1878.	Lebanon, 1878.
For the entire year,	47·85	44·72	37·23	36·46
For July, Aug. and Sept.,	9·34	11·56	6·65	4·14

Table A.—*Inches of Rainfall.*

Months.	Philadelphia.		Reading.	Lebanon.
	1858.[1]	1878.	1878.	1878.
January,	3·12	4·57	5·01	3·47
February,	2·75	2·17	2·43	2·76
March,	1·31	3·64	3·44	3·61
April,	5·57	2·54	2·75	3·62
May,	6·01	4·33	3·48	5·12
June,	5·40	4·75	2·73	3·60
July,	1·62	5·31	1·63	1·24
August,	5·93	4·83	1·84	1·99
September,	1·79	1·42	3·18	·91
October,	2·21	2·39	3·74	3·33
November,	6·74	2·89	2·63	2·89
December,	5·40	4·87	4·37	3·92
Total,	47·85	44·72	37·23	36·46

Note.—Observations of rainfall at Philadelphia were taken at + 35 city datum.
Reading, ... +250 "
Lebanon, ... +500 "

Substituting the rain fall at Lebanon in 1878 in Mr. McAlpine's table B, we find that for a daily average consumption of 150 millions of gallons per day the storage required is 12·097 millions of gallons (table C), and not 7057 millions (table B), and a storage of 18·804 millions for an average consumption of 200,000,000 of gallons per day.

[1] Estimated at one-fifth greater than recorded.—See table B.

To provide for this storage, and to elevate the conduit that it may deliver water at an elevation of 170 city datum, will require a very high dam if located at Schwencksville.

That we may avoid this contingency and, at the same time, utilize the entire drainage area above Schwencksville, an intercepting canal could be built around what would have been the edge of the proposed collecting lake, and dams built across such valleys as may be utilized for storage and subsidence.

A dam either at Green Lane, on the main stream, or one on Swamp Creek above the village of Zieglerville, would be sufficient to store all the water required for the summer months; a dam at either of these points would collect all the rain-fall on one-third the entire drainage area above Schwencksville; and all the water stored by these dams could be used, as the bottom of the valley would be above the elevation of the conduit or collecting canal.

The amount collectable above either of these proposed sites, calculated from the same data as table C, is as follows, considering 73 square miles the available drainage area.

Jan.,	4·160	For these months the other two-thirds of the total drainage area is sufficient to keep up the supply.
Feb.,	2·960	
March,	3·340	
April,	2·893	
May,	3·446	
June,		For these months the entire area is not sufficient to keep up the supply.
July,		
August,		
Sept.,		
Oct.,	2·666	For these months the other two-thirds is sufficient to keep up the supply.
Nov.,	3·080	
Dec.,	4·706	
	27·251	= the total amount that can be collected from one-third the total drainage area to be drawn upon during the months of June, July, August and September.

This plan would destroy neither the railroad nor valuable property which has sprung up in the valley since the project was first suggested, and which has been urged against the gravity plan with some force.

The elevation of the dam and the location of the conduit depends upon the distribution of the water in the city. Care should be taken to prevent the extra expense of pumping to any but sparsely-

inhabited and limited high districts, and to utilize the reservoirs and mains in existence.

An examination of the topography of the city develops the fact that by far the greater area, and the thickly-populated and growing districts, are below an elevation of 120 feet, city datum. Fifty feet above the curb is the minimum that should be allowed for a proper supply. Such an allowance would make the city distributing reservoirs 170 feet city datum; adding to this 30 feet for the grade required by the conduit, makes the minimum elevation of the collecting reservoirs 200 feet city datum.

Proposed Conduit Location.

The conduit, starting from the collecting canal or reservoirs, leaves the Perkiomen Valley above Collegeville, crosses under Evansville with a tunnel four-tenths of a mile long, to the Skippack Creek, crossing which it follows a direct line, by a tunnel 4 miles long, to a branch of Stony Creek above Norristown, passing back of Norristown, with easy work, over the waters of Stony Creek, Saw-mill Run, Mogee Creek and Plymouth Creek, and, by a tunnel three-fourths of a mile long, into the valley of the Wissahickon, thence to the terminus in the city. Passing back of all the towns on the route, and avoiding the long detour made by the river, the distance is shortened from 33 to 27 miles.

The cost of the long tunnel is fully compensated by avoiding the expensive route below Norristown on the river route, the short line and the fact that no heavy expense is incurred by constructive damages nor any danger from infiltration of sewage, both of which would be unavoidable if it became necessary to pass through any of the towns upon the route.

The location described may be determined from the surveys made in 1865 by Mr. Birkinbine, and those made in 1875 by the writer, under the direction of the Board of Experts, although the surveys of 1875 looked to the East Park reservoir as a terminus, at an elevation of but 133 feet, city datum, sustaining ground for this route, and a conduit delivering at an elevation of 170 feet, city datum, can be obtained at no greater cost.

The Distribution.

By dividing the city into districts in harmony with the topography and existing reservoirs, an equable range of water-pressure can be maintained, and the three systems, each of about an equal area of distribution, are developed.

The first system, which at present consumes the most water, is, approximately, all the area of the city below a curb of 60 feet, city datum, and is at present supplied by 4 basins:—Fairmount at 96, Corinthian at 120, Spring Garden at 120, Delaware at 114—to be supplemented by a fifth, the East Park Reservoir at 133 feet, city datum.

The second system, or the area lying between the first system and a curb-height of 120 feet, city datum, is the growing section of the city, and is supplied by but two basins—the Belmont at 212, and the Wentz Farm at 167 feet, city datum—7½ miles apart.

The third system lying above the second system, is suburban and likely to remain sparsely settled; it is supplied by two basins, the Roxborough at 366, and the Mt. Airy at 365 feet, city datum.

The first and second systems can be supplied by gravity; the third, ranging in curb-heights from 120 feet to 400 feet, city datum, must be supplied by pumping.

A pumping station in the Wissahickon Valley, at the crossing of the 20″ main connecting the Roxborough and the Mt. Airy Basins, would supply these basins, pumping from a conduit against a head of 200 feet.

The connecting-main could thus be utilized as a pumping-main to each of these basins, and the machinery in the Department for power. The auxiliary works to this system to be retained as at present. The first and second systems would be supplied from the distributing reservoirs or conduit.

A main, *A*, stretching to the east, commanding all the high ground between Twentieth and Cambria and the Wentz Farm Reservoir, and another, *B*, to the west, connecting with the submerged main, the present mains from the Belmont pumping works and the West Philadelphia distribution, would supply the second system. The first system would be supplied, as at present, from the existing basins, which would receive their supply from the conduit through mains *C* to the Delaware basin and *D* to the East Park reservoir. Mains laid from the

East Park reservoir and connecting with the pumping mains from the Spring Garden works would make the connection with all the other basins complete. All the other pumping mains could then be used in the distribution.

The only reservoir not utilized by this plan is that at Belmont, 212 feet, city datum. Its elevation is too high to be supplied from the conduit and too low to be of use to the high ground in West Philadelphia, which, by any plan, must be supplied by an auxiliary works.

These auxiliary works would be located at the Belmont basin, if the present plan of pumping obtains in the future; if the supply is to be by gravity, they would be located on Belmont avenue and the present pumping mains.

CAPITAL.

To determine the amount of capital to be expended in the construction of a gravity supply, so that it may compare in cost with an extension of the present works, we must not consider that which has been invested—first, because the pipes and reservoirs would be common to both plans, and, second, the adoption of a gravity scheme would destroy the present pumping works.

If the price of pumping per million gallons includes the interest on the plant, the question of capital invested for the construction, from time to time, of new pumping machines, would, of course, be covered.

The cost of steam pumping has been reduced to $7.50 per million gallons per 100 feet high. This, substituted in Mr. McAlpine's table D, shows (table E) that, to compare favorably with pumping, the capital invested in a gravity scheme for Philadelphia, if delivered at an elevation of 133 feet, city datum, should not be more than

$1,800,000	for a	daily average	supply of	50,000,000	gals.
3,000,000	"	"	"	75,000,000	"
4,200,000	"	"	"	100,000,000	"
6,500,000	"	"	"	150,000,000	"
8,500,000	"	"	"	200,000,000	"

Whereas, if the water is delivered by gravity to the city, at an elevation of 170 feet, city datum, (see table F),

$2,000,000	could	be expended	for a supply of	50,000,000	gals.
3,400,000	"	"	"	75,000,000	"
5,300,000	"	"	"	100,000,000	"
7,400,000	"	"	"	150,000,000	"
9,500,000	"	"	"	200,000,000	"

Inasmuch as $7,500,000 is the lowest estimate for a gravity supply, it is evident that a supply by pumping is the most economical until the quantity needed is 150,000,000 gallons per day, or about the year 1950.

Upon the assumption that the completed conduit, to carry a maximum of 180,000,000 or a daily average of 150,000,000 gallons, will cost $10,000,000,

The daily expense interest alone will be .	$1630 00
Or, per million gallons, . .	10 86
Pumped by steam alone, it would cost, at an elevation of 170 feet, . .	12 75
And by water-power and steam, . .	11 00

At the present time:

Interest per day on $7,500,000, . .	$1233 00
Cost per million . . .	22 42
Cost by steam, 170 feet high, . .	12 75
Cost by water and steam, as it is, .	10 00

TABLE B.—*Storage Capacity required for the Perkiomen Reservoir (McAlpine).*

MONTHS.	Philadelphia Rainfall in 1858.	Estimated Rainfall on the Perkiomen one-fifth greater.	Percentage of Rainfall collectable in each month.	Inches of Rainfall collectable.	Millions of gallons collectable into the reservoir from 220 square miles.	Inches of evaporation from the surface of the lake for each month.	Evaporation in million gallons.	Waste and loss from all causes.	Percentage of consumption per month.	Consumption at an average of 150 million gallons per day —Million gallons.	Total demand from reservoir —Million gallons.	Surplus.—Million gallons.	Deficiency.—Million gallons.
January	2·60	3·12	80	2·81	11,240	1·15	63	30	82	3,690	3,783	7,457	
February	2·29	2·75	80	2·20	8,800	1·65	90	30	83	3,735	3,855	4,945	
March	1·09	1·31	70	0·92	3,680	0·82	45	30	85	3,825	3,900	....	220
April	4·64	5·57	60	3·34	13,360	2·07	112	30	94	4,230	4,372	8,987	
May	5·01	6·01	50	3·00	12,000	1·62	88	30	105	4,725	4,843	7,157	
June	4·50	5·40	40	2·16	8,640	7·10	386	30	115	5,175	5,591	3,049	
July	1·35	1·62	30	0·49	1,960	6·75	368	30	120	5,400	5,798	....	3,838
August	4·94	5·93	20	1·19	4,760	7·79	424	30	115	5,175	5,629	....	869
September	1·49	1·79	40	0·72	2,880	5·41	295	30	109	4,905	5,230	....	2,350
October	1·83	2·21	60	1·33	5,320	7·40	403	30	104	4,680	5,113	207	
November	5·62	6·74	80	5·39	21,560	3·95	215	30	100	4,500	4,745	16,815	
December	4·50	5·40	90	4·86	19,440	3·66	199	30	88	3,960	4,189	15,251	
Aggregates and averages	....	47·85	59¼	28·41	113,640	49·37	2,688	360	100	54,000	57,048	63,808	7,057

TABLE C.—*Storage capacity of Perkiomen Reservoir.*

MONTHS.	Rainfall, Lebanon, 1878.—Inches.	Percentage collectable.	Collectable.—Inches.	Millions of gallons collectable from 250 square miles.	Total demand from Table B, 150 million gallons per day.	Surplus.—Million gallons.	Deficiency.—Million gallons.	Total demand, 200 million gallons per day.—Million gallons.	Surplus.—Million gallons.	Deficiency.—Million gallons.
January	3·47	90	3·12	12,480	3,783	8,697	....	5,013	7,467	
February	2·26	80	2·22	8,880	3,855	5,025	....	5,100	3,780	
March	3·01	70	2·53	10,120	3,900	6,220	....	5,175	4,945	
April	3·62	60	2·17	8,680	4,372	4,308	....	5,782	2,898	
May	5·12	50	2·56	10,240	4,843	5,397	....	6,418	3,822	
June	3·60	40	1·44	5,760	5,591	167	....	7,316	....	1,556
July	1·24	30	·37	1,480	5,798	....	4,318	7,589	....	6,109
August	1·99	20	·40	1,600	5,629	....	4,029	7,354	....	5,754
September	·91	40	·37	1,480	5,230	....	3,750	6,865	....	5,385
October	3·33	60	2·00	8,000	5,113	2,887	....	6,673	1,327	
November	2·89	80	2·31	9,240	4,745	4,495	....	6,245	2,995	
December	3·92	90	3·53	14,120	4,189	9,931	....	5,509	8,611	
Aggregates and averages	38·46	59·17	22·02	....	....	....	12,097	....	....	18,804

TABLE D (McAlpine).

The conduit delivering at an elevation of **135**, *city datum, shows the expense of pumping* SAVED *by the Perkiomen plan, when the consumption of water is* 50, 75, 100, *and* 150 *millions of gallons per day, considering the cost of pumping by water power at* $3 *per million gallons one hundred feet high, and that by steam power at* **$15.**

Rate of consumption.	No. feet high pumped.	Saving per day on 50 millions of gallons.	Saving per day on 75 millions of gallons.	Saving per day on 100 millions of gallons.	Saving per day on 150 millions of gallons.	Remarks.
		25 M. at $ 3 = $ 75 00	25 M. at $ 3 = $ 75 00	25 M. at $ 3 = $ 75 00	25 M. at $ 3 = $ 75 00	
70	100	10 at 15 = 150 00	27½ at 15 = 412 50	45 at 15 = 675 00	80 at 15 = 1,200 00	All water delivered to the first system.
		35 M. $235 00	52½ M. $487 50	70 M. $750 00	105 M. $1,275 00	
20	135	10 M. at $20.25 = $202 50	15 M. at $20.25 = 303 75	20 M. at $20.25 = 405 00	30 M. at $20.25 = 607 50	Water pumped from Fairmount pool to 135 feet.
10	105	5 at 15.75 = 78 75	7½ at 15.75 = 118 12	10 at 15.75 = 157 50	15 at 15.75 = 235 25	Water pumped from Flat Rock pool to 135 ft. from 30 ft. c. d.
100		$506 25	$909 37	$1,312 50	$2,118 75	
		$506.25 x 365 = $184,781.25	$909.37 x 365 = $331,923.70	$1,312.50 x 365 = $479,062.50	$2,118.75 x 365 = $773,343.75	Cost of pumpage per year, being the interest at 6 per cent. on following capital:
		$3,079,687 50	$5,532,061.66	$7,984,375.00	$12,889,062.50	Capital.

TABLE E.

The conduit delivering at an elevation of **135**, *city datum, shows the expense of pumping* SAVED *by the Perkiomen plan, when the consumption of water is* 50, 75, 100, 150 *and* 200 *millions of gallons per day, considering the cost of pumping by water power at* \$3 *per million gallons one hundred feet high, and that of steam power at* **\$7.50.**

Ratio of consumption.	Saving in pumping.—Feet.	Saving per day on an average consumption of 50 millions of gallons.	Saving per day on an average consumption of 75 millions of gallons.	Saving per day on an average consumption of 100 millions of gallons.	Saving per day on an average consumption of 150 millions of gallons.	Saving per day on an average consumption of 200 millions of gallons.	Remarks.
70	100	25 M. at \$3.00 = \$ 75 00	25 M. at \$3.00 = \$75 00	25 M. at \$3.00 = \$ 75 00	25 M. at \$ 3.00 = \$75 00	25 M. at \$ 3.00 = \$ 75 00	All water delivered to the first system.
		10 at 7.50 = 75 00	27½ at 7.50 = 206 25	45 at 7.50 = 337 50	80 at 7.50 = 600 00	115 at 7.50 = 762 50	
		35 M. \$150 00	52½ M. \$281 25	70 M. \$412 50	105 M. \$675 00	140 M. \$339 50	
20	135	10 at 10.12½ = 101 25	15 at \$10.12½ = 151 87½	20 at 10.12½ = 302 50	30 at 10.12½ = 303 75	40 at 10.12½ = 405 00	Water pump'd from Fairm'nt pool to 135 feet.
10	105	5 at 7.87½ = 39 37½	7½ at 7.87½ = 59 06	10 at 7.87½ = 78 75	15 at 7.82½ = 118 12½	20 at 7.87½ = 107 50	Water pump'd from Flat Rock pool to 170 feet.
100		50 M. \$200 62½	75 M. \$492 18½	100 M. \$693 95	150 M. \$1,006 87½	200 \$1.399 00	Daily saving.
		\$106,078.12½	\$179,645.90	\$253,218.75	\$390,359.37½	\$510,635.00	Yearly saving.
		\$1,767,968.75	\$2,994,095	\$4,220,312.50	\$6,505,989.58	\$8,510,583.33⅓	Capital.

TABLE F.

The conduit delivering at an elevation of **170**, *city datum, shows the expense of pumping* SAVED *by the Perkiomen plan, when the consumption of water is* 50, 75, 100, 150 *and* 200 *millions of gallons per day, considering the cost of pumping by water power at* $3 *per million gallons one hundred feet high, and that by steam power at* **$7.50.**

Ratio of consumption.	Saving in pumping—Feet.	Saving per day on an average consumption of 50 millions of gallons.	Saving per day on an average consumption of 75 millions of dollars.	Saving per day on an average consumption of 100 millions of gallons.	Saving per day on an average consumption of 150 millions of gallons.	Saving per day on an average consumption of 200 millions of gallons.	Remarks.
70	100	25 M. at $ 3.00 = $ 75 00	25 M. at $ 3.00 = $ 75 00	25 M. at $ 3.00 = $ 75 00	25 M. at $ 3.00 = $ 75 00	25 M. at $ 3.00 = $ 75 00	All water delivered to the first system.
		10 at 7.50 = 206 25	27½ at 7.50 = 206 25	45 at 7.50 = 337 50	80 at 7.50 = 600 00	115 at 7.50 = 762 50	
		35 M. $150 00	52½ M. $281 25	70 M. $412 50	105 M. $675 00	140 M. $837 50	
20	170	10 at 12.75 = 127 50	15 at 12.75 = 191 25	20 at 12.75 = 255 00	30 at 12.75 = 382 50	40 at 12.75 = 510 00	Water pump'd from Fairm'nt pool to 170 feet.
10	140	5 at 10.50 = 52 50	7½ at 10.50 = 78 75	10 at 10.50 = 105 00	15 at 10.50 = 157 50	20 at 10.50 = 210 00	Water pump'd from Flat Rock pool to 170 feet.
100		50 M. $330 00	75 M. $551 25	100 M. $872 50	150 M. $1,215 00	200 M. $1,557 50	Daily saving.
		$120,450.00	$201,106.25	$318,362.50	$443,475.00	$568,487.50	Yearly saving.
		$2,007,500.00	$3,351,170.83⅓	$5,306,041.00	$7,391,250.00	$9,476,791.66	Capital.

XVII.

ROCK-SALT DEPOSIT

OF HURON AND BRUCE COUNTIES, ONTARIO, CANADA.

Abstract from a paper by JOHN HY. HARDEN, M.E., Member of the Club.

Read May 3d, 1879.

The town of Goderich, in the county of Huron, is situated on the eastern shore of Lake Huron, on the south bank of the river Maitland, at an elevation of 105 feet above the lake. The surrounding country is entirely devoted to agriculture, its contour generally level and the town covers a considerable area of ground, having wide streets and buildings of a superior character. (Map shown.) It is orderly, neat, clean, and has some reputation as a summer resort.

The Buffalo & Lake Huron Branch of the Grand Trunk Railroad from Fort Erie to Goderich (161 miles) terminates within the harbor of Goderich, intersecting the main line at Stratford, communicating with the railroad systems of both Canada and the United States.

The harbor accommodation for shipping freight by water to all the principal points on the Great Lakes are all that can be desired. A glance at any good map will show the commercial importance of the situation, having in view the distribution of salt, or other product, both by rail and water, with the prospect of competing more successfully with imported and other salt producing districts less favorably endowed by nature than Goderich.

The first notice referring to the geology of the Ontario salt region will be found in a report by Dr. T. Sterry Hunt to the Director of the Geological Survey of Canada, and will be found in the published work of the Survey, together with notices of the occurrence of rock-salt in the United States, etc. Salt was first discovered at Goderich on the 19th of May, 1866, in prospecting for oil, at a depth of 964 feet, by Mr. Samuel Platt. In the year following, salt was discovered at Clinton, 13 miles east, and in the succeeding year at Kincardine, in the county of Bruce, 30 miles to the north-west, at the depths of 1136 and 900 feet respectively. At this date there are sixteen wells whose combined product would probably reach 75,000 tons per annum, all of which is made from brine. Hitherto one-half the product has been exported to the United States, paying a duty of \$1.60 per ton.

The consumption of salt in the United States is about 47½ pounds per capita, and by some authorities it is estimated as high as 50 pounds. This large consumption is due in a great measure to its cheapness, together with the large quantity used in salting meats that are exported to other countries. The consumption of salt in the United States of all kinds and from all sources in 1877 was 990,129 gross tons; of this quantity 417,627 tons, or 20 pounds per capita, were imported from England, estimating the population as 46,624,000. If we estimate the consumption of the Dominion of Canada after the same rate we must add one-tenth, and the total consumption in the two countries would be 1,089,142 gross tons.

The production of salt of all kinds in the United Kingdom of Great Britain during the years 1872 to 1876, both included, was 9,990,964 tons, valued at $24,332,689, an average of $2.43 per ton; during the same time 1,015,710 tons were exported to the United States and 306,724 tons to British North America. In the soda manufacture in 1876 were consumed no less than 538,600 tons.

Production in the five principal salt districts of the United States, 1877:

	Bushels.
Michigan,	8,304,485
New York,	6,427,983
West Virginia,	4,837,325
Ohio,	2,400,350
Pennsylvania,	579,970
Total,	22,550,113

= 563,753 gross tons. This large product was obtained from brine by the process of evaporation.

Chemical products imported into the United States in the years 1875, 1876, 1877 and 1878 were as follows:

Year.	Quantity in Pounds.	Value, including duty.
1875	303,257,928	$7,978,412
1876	278,972,675	6,470,409
1877	317,706,958	6,641,851
1878	334,050,396	6,433,217
Total,	1,233,987,957	$27,523,889

During these years the imports into the Dominion of Canada were of the value of more than one million dollars.

Within the last few years the rock-salt of Goderich has been thoroughly prospected by the Pennsylvania Diamond Drill Company, who have taken out samples (cores) of salt from the several beds (samples shown). These have been analyzed by Dr. T. Sterry Hunt, and pronounced by that gentleman as fit for mining. (See transactions of the American Institute of Mining Engineers.)

The following is a section of the beds relative to the surface-level (about 40 feet above the lake):

	ft.	in.		ft.	in.		ft.	in.
First bed,	30	11	from	997	0	to	1027	11
Second bed,	25	4	"	1060	0	"	1085	4
Third bed,	34	10	"	1092	2	"	1127	0
Fourth bed,	15	5	"	1207	7	"	1223	0
Fifth bed,	13	6	"	1230	0	"	1243	6
Sixth bed,	6	0	"	1379	0	"	1385	0

The first consideration in the development of mining operations would be the shaft-sinking, always an important but rarely a difficult operation in ground free from water, yet under the conditions known to exist would require special skill and appliances for overcoming the large feeders of water known to exist within the depth of 400 feet from the surface.

A recent trial under the English system of sinking and pumping the water until an impervious strata is met with, upon which to found the water-tight lining (tubbing), has already proved its impracticability within estimates to be relied upon. In this attempt, after spending nearly $70,000 and attaining a depth of about 150 feet, with a clear diameter of 10 feet 6 inches, the work was abandoned in consequence of the overpowering influx of water under conditions not provided for. The writer, therefore, is of opinion that no known method of dealing with such a work is so applicable as that of "Kind Chandran," described in the Transactions of the American Institute of Mining Engineers by Mr. Julian Déby. By this process, already well established in other countries, reliable estimates can be formed as to the cost and duration of the work.

In comparison with mines in this country, in England and on the continent of Europe, 400 yards is not very deep

The deepest mine in the United States is on the Comstock Lode, Nevada, 783 yards. In England, Rosebridge Colliery, Lancashire,

815 yards. On the continent of Europe, Adalbert, Austria, 1093 yards. Proposed shaft at Goderich, 400 yards.

Depth has been found to interfere with mining operations only when adequate provisions for ventilation and drainage have been wanting.

The construction of the ingress or egress to a mine is of the utmost importance. Through it we not only raise the mineral, pump the water and ventilate the workings, but it is also the means of entrance or exit for those engaged in mining. Shafts are sunk in various shapes and sizes, the circular form being best adapted to sustain heavy pressures. The design of twelve feet will give ample accommodations for hoisting, ventilation and drainage. There are, however, objections to single shafts, as it affords but one outlet for those working underground; for that reason the mining laws of England and Pennsylvania permit operations to be carried on through a single opening only under certain restrictions. There is less objection to a salt mine worked through a single outlet than to a coal mine, for which these laws were especially framed, for obvious reasons. The depth from the surface and the impervious strata between the salt beds and the feeders of water will protect the workings from any influx from that source. Proper pillars of extra size will be allowed to remain to protect the shaft.

The known regularity of the salt beds, proved by a number of bore holes in different locations, and the observed regularity of the stratification agree so well that we may feel confident that mining may be carried on with success.

Mining will be regulated by the demand and the seasons of navigation on the Lakes, usually from six to seven months.

The plant designed for this work contemplated a speed for hoisting the mineral at 2000 feet per minute, extracting in cars of two tons each, 100 tons per hour or 1000 tons per day; for 200 days = 200,000 tons. The speed of hoisting 2000 feet per minute, 33$\frac{1}{3}$ feet per second or nearly 23 miles an hour, is much exceeded in many coal mines. The engines at the Rosebridge Colliery, Lancashire, lift coal from a depth of 2418 feet in 55 seconds = 43$\frac{96}{100}$ feet per second, nearly 30 miles an hour.

The specific gravity of the rock-salt in question, as given by Dr. T. Sterry Hunt, is 2·125, and a square acre one foot thick would yield 2582 gross tons. The second bed of salt, described by the same authority, as "entirely fit for mining, and in some parts of remarkable purity: chloride of sodium 99·687, chloride of calcium ·032, chloride

of magnesia ·095, sulphate of lime ·090, insoluble in water ·017, moisture ·079, or less than one-quarter of one per cent. of impurity; it is 25 feet 4 inches thick." The third bed, 34 feet 10 inches thick, is described as "somewhat less pure, but with a little care in sorting might probably be used for all ordinary purposes." These two beds could be mined together, leaving a stratum of salt in the roof and floor of both, the pillars in each working being directly above or below the other; by this means 20 feet of the second and 25 feet of the third bed could be wrought with advantage deducting 33 per cent. for pillars, the product from one acre would yield 37,342 gross tons. The absence of noxious gases, so freely generated in coal mines, as well as those conditions requiring the use of large quantities of timber for supports are advantages to be considered.

At the present time the cost of mining should not exceed eighty cents or one dollar per ton, as follows:

Miner, 6 days, @ $1.50, . .	$9 00
Laborer, 6 days, @ $1.00, . .	6 00
Supplies, 6 days, . . .	3 96
Total, ...	$18 96

Estimating the product of six days' work at 60 tons = $31\frac{36}{100}$ cents per ton.

Estimated cost of producing one ton of salt fit for market:

Mining, ...	31·36 cts.
Putting, . . .	20·64 "
Preparing, ...	28·00 "
Total cents, ...	80·00

In 1877 the cheapest product of American salt (Michigan), much inferior to that of Goderich, sold for fifty to sixty cents per barrel of 280 pounds = $4.40 per ton. This cheap rate of production is, in a great measure, due to the use of an otherwise waste product (slabs, sawdust and exhaust steam from the lumber mills) as fuel. Necessarily there will come a time when this source of fuel will be exhausted.

In 1877 New York salt sold for the lowest price ever known before that date, 79 cents per barrel = $6.32 per ton. In 1878 Mr. A. C. Powell, superintendent of the Onondaga Salt Springs, states the results of the year's work to be 50 to 55 bushels of salt per ton of coal, costing eight cents per bushel = $3.20 per ton. If these figures are cor-

rect, it is scarcely possible that Michigan can produce so cheaply. In 1877 the lowest value ever realized on imported salt, including duty, was $9.30 on packages and $4·48 per ton in bulk. The average value of salt imported into Canada during the year ending June, 1877, was $4.66 per ton. The lowest price for which salt has ever been sold at Goderich was $2.40 per ton, f.o.b. To this, if exported to the United States, add $1.60 duty, total $4.00. The price now, April, 1879, is $3.00 per ton, f.o.b. From these figures we may safely estimate the cost of mining and preparing at $1.00 and the selling price, f.o.b., $2.40.

The total estimated cost of opening a mine equal to the extraction of 200,000 tons per annum would be $250,000; time, 3½ years; capital required, $350,000 to $400,000. Lands of a fine agricultural character, underlaid with rock salt, can be purchased for $400 per acre.

Within a year rock-salt has been discovered near the village of Wyoming, on the Rochester and State Line Railroad, in the State of New York. It was penetrated in search of oil, at the depth of 1270 feet, and is said to be 70 feet thick. An analysis of a sample by F. E. Englehardt, Ph.D., chemist to the Dairy Salt Company, of Syracuse, is as follows: insoluble matter 3·276, sulphate of lime 1·696, chloride of calcium ·413, chloride of magnesium ·556, moisture and loss ·319, pure salt (chloride of sodium) 93·740. Thus there are nearly 6 per cent of impurities, while the Goderich salt contains less than ¼ of one per cent.

NOTES AND COMMUNICATIONS.

IRON RAILWAY CROSS TIE.

Regular Meeting, March 15th.—Mr. C. E. Buzby exhibited a model of an ingenious device in the shape of an Iron Railway Cross Tie, now in use on one of the sharpest curves of the Philadelphia & Baltimore Central Railroad, between Lamokin and Port Deposit. It is invented by Thos. W. Travis, of Philadelphia.

The device dispenses with all spikes, bolts, nuts or fish-plates, and with all drilling or punching of the rails, avoiding incipient fractures from such causes. At the same time, the iron tie is claimed to outlast twelve renewals of the ordinary wooden tie, and to require but one-half the expense of labor to keep in repair.

The construction of the tie was briefly described, as follows: Each tie is recessed under its rails, and along the bottom of these recesses wedge-shaped pieces are cast transversely. At the sides of each recess are creosoted oak blocks which form an elastic cushion, and at the same time a fulcrum for two clamps, which grasp the flange and web of the rail above and bear upon opposite faces of the wedge below. The weight of a train passing over the rails forces the clamps down upon the wedge, which spreads them at the bottom and causes them to take a corresponding grip on the rail—and the greater the weight, the greater will be this resulting grip.

Such a system of ties and rails is said to be firm and secure in service in all seasons, to be quickly and easily laid or partially removed, and to insure smooth and easy riding in the cars.

The ties may be ballasted over to the depth of five or seven inches, which secures them from accident by cars getting off the track, and, if desired, the boxes containing the clamps may be united by a cast or wrought iron bar and pins, instead of the solid casting.

The first cost of this tie is somewhat greater than for the wooden tie, but owing to the great durability claimed for it, and the economy in labor for repairs, it is said to effect an immense saving in a term of years.

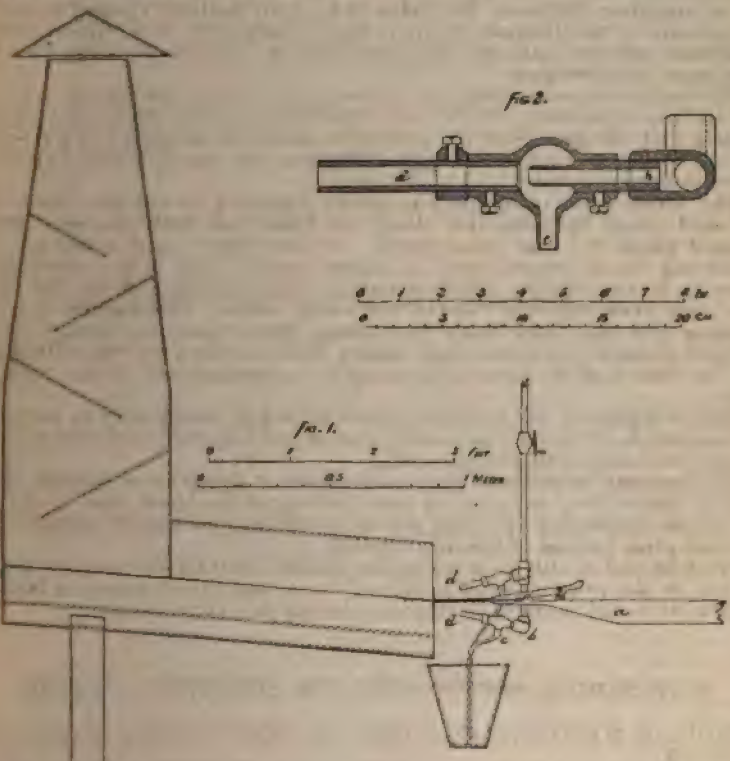
THE SAND-BLAST PROCESS FOR SHARPENING FILES.

Regular Meeting, March 15th.—Mr. Wm. A. Cooper presented the following:

"The Sand-blast has been used a number of years for a variety of purposes, but its application for sharpening files and other edge tools is unique and of recent origin. There is, however, really less difference than at first suggests itself between grinding metal with sand in the solid form of the grindstone and grinding with the same material in the finely pulverized condition, impelled by air or steam blast; for file sharpening, at least, it will be seen that the sand blast has capabilities which no grindstone or grinding process can possibly equal.

"The operation is very simple: The shank of the file to be sharpened is held by a clamp to the arm *a*, which by a suitable mechanism is given a slight lateral motion at the same time that it is being moved forward or back, so as to present all parts of the file equally to the action of the jets of steam and sand, which are thrown against the back of the teeth by two guns, placed, one above and the other below, at an angle of about 15° to the file. The action of these guns is similar to that of the injector; the steam passes through the pipe *b*, the sand and water are drawn through

the tube *c* from a box below, filled with sand and water. They together pass through the nozzle *d* and are thrown against the file. This nozzle, which in time becomes worn through by the action of the sand, is made so that it can easily be replaced. Ground flint is used of the same grade as for 1½ sand paper. Natural water-washed sand is not sharp enough. The steam should be under high pressure, as the higher the pressure of steam the greater the velocity of the blast. It has been found that it takes nearly twice as long to sharpen a file with steam at 70 lbs. pressure as it does with steam at 90 lbs.



"In the stack for the exhaust steam are boards, placed to prevent the sand being carried out at the top; so, instead of being wasted, it is carried by the condensed steam back into the box to be used over again.

"As the sand is thrown against the whole surface of the tooth, the question naturally arises: Why, as the point of the tooth is the highest and most exposed to the blast, it is not cut away the most, with the obvious result of dulling instead of sharpening the tooth? Practice shows that this is not the case. The only theory given is that the effect of the sand blast is in some measure proportionate to the resistance offered. Thus, a layer of rubber varnish, or even a piece of paper, will turn a blast which cuts the hardest material, simply because the particles of sand rebound from the elastic surface. Now a file tooth, from its wedge-shaped form, may be regarded as offering a constantly decreasing resistance from base to point, the latter becoming as it were more and more spring-like. The consequence is that while the sand cuts into the resisting base, its force is

decreased by the yielding and elasticity of the point; hence more metal is ground away at the base than at the point.

"The tooth is left in very good condition for use, as sharp as if it were ground and oil-stoned, and far better than it is possible to make it with a chisel. New files are greatly improved by being sharpened with the blast, as it removes the burr from the top of the tooth that the chisel always leaves. Old files, provided the teeth are not too much worn, are made sharper than new files not treated with the sand blast, without disturbing the original temper, and at about one-half the cost of recutting.

"Although a file may be sharpened by this process many times, yet the number is limited, as each time it is sharpened the tooth becomes a little more shallow. It is impossible to say how many times a file may be sharpened profitably, as that depends upon the quality of the file, and how badly it is worn each time.

"It is generally conceded that it does not pay to have files recut, as it costs nearly as much as the price of new files, and they are never as good. By the cheapness of this process files can be sharpened as frequently as they become partially dulled, and thus the advantage of always using sharp files is gained.

"There is no economy in using dull cutting tools, and the file is no exception to this rule."

THE USE OF HELIOTROPES FOR SIGNALING.

REGULAR MEETING, APRIL 5th.—Prof. Robert Fletcher, corresponding member, communicated the following:

* * * "Within the past few months has appeared in the *Journal of the Franklin Institute*, and other periodicals which have copied it, a statement concerning the construction and use of heliotropes in surveying, and the facilities which they offer for telegraphing, due, I believe, to Professor Haupt. I wish to state that as long ago as 1871 I used heliotropes in the triangulation of this State,[1] then going forward under the immediate direction of Prof. E. T. Quimby, for the U. S. Coast Survey. Their adaptation to telegraphing was so obvious that we used them at once for that purpose, adopting the Morse code. We afterwards learned that the Coast Survey and War Department Surveys had used them for signaling, although we were ignorant of the fact at that time. In 1873 we had daily communication, at Hanover, with parties of observation 20 and 30 miles distant, when the sun permitted, noon being the set time. Prof. Quimby's parties have sent messages more than 70 miles by repeating at one intermediate station. On one occasion an important letter was received from Washington and "heliographed" at once (in a few minutes) to a party in the field, 20 miles distant. Its transmission by telegraph to the nearest station, and by messenger to the top of the mountain, would have consumed half a day at least. The large reconnoitering telescope (2 in. objective) of the Coast Survey, used by the parties in New Hampshire, has a special heliotrope attachment to put on to the telescope. By this means the reflection can be directed with unerring precision to the exact spot desired, whether near or far distant."

THE SYSTEM OF TELEPHONE EXCHANGE.

REGULAR MEETING, MAY 3d.—Mr. Arthur Green communicated the following to the Club:

"The manner of operating the Telephone Exchange has as yet hardly reached perfection, and alterations are being made every day as we see where improvement can be made or time saved for our subscribers. I will

[1] New Hampshire.

endeavor to explain the mode of operating, as done at the present time. Each wire (excepting special lines) accommodates three subscribers, and each subscriber has a given signal, in rings on the bell call. Every bell on the line will ring when a call is given, but is only answered by the party to whom the signal belongs. When the subscriber at the end of the line uses the instrument, the electric current passes through the intermediate bells, and, therefore, the other subscribers on the line cannot hear what passes.

When an intermediate station uses the instruments, the line is grounded at that station, and for the time it becomes the terminus of the line, and all stations behind are entirely cut-off from communication with the exchange office. No two subscribers on the same wire can talk together. The bell-call now used has a lever with a hook on one end, and on this hook the telephone hangs when not in use. The weight of the telephone on one end of the lever keeps the other end in contact with a platina spring on the inside of the box and thus the bell is held in circuit. When the telephone is taken from the hook, the lever moves and the end inside the box leaves the first spring and makes contact with a second which brings the telephone in circuit. The lever, in moving, brakes contact with one spring before striking the other, and by this simple device no subscriber can hear what is passing over the wire from any other stations on the line.

In the Exchange Room each wire is connected to a strip of brass on the switch-board, and by a plug is carried to the communicator. Every wire coming into the exchange is connected in this way. When a call is given the annunciator shows the number of the wire. The plug connecting the annunciator is then removed and put in a hole connecting the telephone, and the wants of the subscriber are noted. One set of instruments works all the wires on a switch-board. If the party calling wishes to communicate with any other subscriber, the plug is again removed and replaced with a pliable wire cord. The telephone is then plugged into the line going to the station wanted, and is called by the signal for that place. Then this party answers, the other end of the cord is connected and the two subscribers are in communication on a continuous, and for the time, a private wire.

When the conversation is finished, the party who first called rings the bell once and thus notifies the office. The cord is then removed and plugs replaced which connect the annunciator."

MINUTES OF MEETINGS.

Of the Club.

April 5th, 1879.—A regular meeting was held at 8.30 P. M., Mr. Stauffer in the chair, 21 members present. A letter was read from Prof. Fletcher, of Dartmouth College, Corresponding Member, on the subject of "Heliotropes." Prof. Haupt read a paper on the "Nomenclature and Classification of Masonry." Mr. Cleemann read a paper on "The Proper Amount of Water-way for Railroad Culverts." Prof. Marks exhibited his adaptation of Peaucellier's Compound Compass to the drawing of circles of large radius.

April 19th, 1879.—A regular meeting was held at 8.20 P. M., with President Clarke in the chair, 27 members present. Mr. Hering presented a discussion on the paper read by Mr. Cleemann at the pre-

ceding meeting. Mr. Percival Roberts, Jr., read a paper from Mr. James Christie, Corresponding Member, on the "Connecting Rod." Mr. Clarke announced the action of the Board of Directors in appointing Prof. Haupt to fill the vacancy in the office of Vice-President. Prof. Haupt expressed his appreciation of the action, and regretted the necessity which obliged him to decline the appointment. Mr. Clarke read an address on the "Future of American Engineering."

MAY 3d, 1879.—A business meeting was held at 8.20 P. M., Mr. Murphy in the chair, 19 members present. The action of the Board of Directors was announced in electing Mr. D. McN. Stauffer Vice-President, Mr. Howard Murphy to fill the vacancy in the Board, and Mr. Charles A. Young to serve as Corresponding Secretary *pro tem.* The following resolution, presented by Prof. L. M. Haupt, was unanimously adopted:

Resolved, That the Engineers' Club of Philadelphia respectfully request the Honorable Senators from that city to lend their endorsement to Senate Bill No. 241, to assist the U. S. Coast Survey in prosecuting its work in this State. The bill has passed its second reading and it is very important that the aid requested, which is only $3500, should be rendered at this session of the Legislature, that a suspension of work upon the survey may be prevented. The results obtained will inure directly to the benefit of the State.

The business meeting was adjourned until May 17th, and a regular meeting held at 9 P. M. Mr. Arthur Green read a paper entitled "The System of Telephone Exchange." Prof. L. M. Haupt exhibited a combined plane table and transit made by Messrs. Heller & Brightly for Mr. Fairman Rogers. By means of some of the modifications, astronomical observations of appropriate correctness may be made. A Locke level, so arranged as to be used on a graduated rod, for rapid and approximately correct leveling, was also shown. Mr. Charles G. Darrach read a paper on "Water Supply," illustrated with maps and charts. Mr. J. H. Harden read a paper on "The Salt Deposit of Huron and Bruce Counties, Ontario, Canada," illustrated with maps, sections and mining plans. Mr. Harden also exhibited several instruments for accurately ruling parallel lines at equal distances from each other and a "Combined Section Liner and Shader" of his invention. Specimens of work done with this instrument were presented. Mr. Rudolph Hering exhibited an instrument for describing arcs of large radius, the invention of Mr. Theodore Scheffler, Mech. Eng., of Paterson, N. J.

OF THE BOARD OF DIRECTION.

MARCH 15th, 1879.—A stated meeting was held in the evening and some routine business transacted.

APRIL 19th, 1879.—A stated meeting was held in the evening. Prof. L. M. Haupt was elected Vice-President in place of Mr. J. B.

Knight, deceased. A committee was appointed to ascertain and report upon desirable rooms for the future use of the Club. Proposals for membership were considered, bills approved and other business transacted.

APRIL 30th, 1879.—A special meeting was held at noon. Resignations of Prof. Haupt, as Vice-President, and Mr. Norris, as Corresponding Secretary *pro tem.* were received and accepted The following gentlemen were elected to fill the vacancies: Mr. D. McN. Stauffer, Vice-President; Mr. Charles A. Young, Corresponding Secretary *pro tem.*, and Mr. Howard Murphy, Director.

CONTRIBUTIONS TO THE LIBRARY.

From the Institution of Civil Engineers, London:

Paterson—Testing of Pipes and Pipe Joints in Open Trenches.
Laws—Railway Bridge over the River Tyne.
Thornton—Method of Blasting Rocks.
Potter—Railway Work in Japan.
Clarke—Iron Bridges of Very Large Span.
Patterson—Best Methods of Railway Construction for the Development of New Countries.
Dobson & Brady—Geelong and Sandhurst Water Supplies.
Longridge—Construction of Heavy Ordnance.
Engineering Progress in Foreign Countries.
Abstract of Papers in Foreign Transactions and Periodicals.

From the Russian Imperial Technic. Society:

Proceedings. 2 vols.

From the Essayons Club:

Publications. 23 papers.

From the Swedish Society of Civil Engineers:

Proceedings.

From the Portugese Society of Civil Engineers:

Proceedings.

From the Canadian Pacific Railway Co.:

Report for 1878.

From the Authors:

Hazel Wilson—Notes on the Internal Improvements of Pennsylvania.
Solomon Roberts—Reminiscences of the First Railroad Over the Allegheny Mountains.

LIST OF MEMBERS.

Additions.

MR. GEORGE R. BUCKMAN, Mech. Eng., Denver, Colorado, was elected Corresponding Member May 17th, 1879.

Changes and Corrections.

BURNHAM, GEORGE, JR., C. E. 500 N. 15th street.

BUZBY, CHARLES E., Mech. Eng. 706 Spruce street.

CLARKE, THOMAS C., C. E. 71 Broadway, Room 72, New York City.

CODMAN, JOHN E., Mech. Eng. Elected January 18th, 1879.

HARDEN, JOHN HY., C.E., M.E. Instructor University of Pennsylvania.

KNIGHT, J. B., Mech. Eng., deceased, was elected April 6th, 1878.

NORRIS, THADDEUS, Mech. Eng. 229 S. 18th street.

PARRISH, EDWARD, C. E. 532 Walnut St. Elected Jan. 18th, 1879.

SELLERS, HORACE W., Architect. 3301 Baring street.

ANNOUNCEMENTS.

Members are requested, in papers read before the Club, to write, in parenthesis, weights or dimensions by the metric system, whenever practicable, in connection with those of the system in general use; also to place a metric scale upon drawings illustrating the papers.

The meetings of the Club will be suspended after June 7th until Oct. 4th.

The Board of Directors will meet during the summer months whenever necessary to transact business.

Election of Members will take place on Oct. 4th and Dec. 6th. Nominations must be presented at any meeting at least four weeks prior to either of these days.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

XVIII.

GANGUILLET AND KUTTER'S FORMULA
FOR THE FLOW OF WATER.

By THOS. M. CLEEMANN, C.E., Member of the Club.

Read June 7th, 1879.

A formula has lately been very strenuously advocated for finding the velocity of the flow of water in channels, which is claimed to be perfectly general in its character, a very panacea in resolving the various complicated conditions which exist. It is called after the names of its discoverers, Messrs. Ganguillet and Kutter, and is said to apply to rough and smooth pipes alike, iron and cement, wood and glass; even canals and rivers are alike subject to its potent power. The very universality of these claims makes one regard it with some suspicion, and the following application of it to some experiments made by Mr. Chas. G. Darrach in the Philadelphia Water Department will prove a touchstone to test its vaunted superiority over other formulas. It may be premised that the experiments were not made with the object of testing any formula, but were merely to obtain information in regard to the cleanness of the various pumping mains in the Department. They are reported at length in a paper read by Mr. Darrach before the American Society of Civil Engineers. Only the first experiment will be taken here, on account of the labor involved in applying the formula; but the process would of course be the same with all the others.

The formula of Ganguillet and Kutter is

$$v = \left\{ \frac{41{\cdot}66 + \dfrac{1{\cdot}8113}{n} + \dfrac{{\cdot}002807}{S}}{1 + \left(41{\cdot}66 + \dfrac{{\cdot}002807}{S}\right)\dfrac{n}{\sqrt{R}}} \right\} \sqrt{RS}$$

in which R is the mean hydraulic radius, S is the slope, and n is a constant. In the experiment $R = \frac{2{\cdot}5}{4}$ and $S = \frac{h''}{L}$; L being the length of the pipe, and h'' the head due to friction or other resistance in the pipe. By substituting the values of v and h'' successively in the formula, we obtain successive values of n, as shown in the last column of the table, page 193, and from which it is seen that n is not constant. If we take the mean of the plus values $n = {\cdot}023$ and substitute in the original equation, and calculate h'', we get the sixth column in the table. These are seen to differ materially from the actual values, and yet n is said to always have a plus value in the formula, increasing with the age of the pipe. If we take the minus value of n (column seven) h'' is nearer to what it should be by the experiments, but still more than ten per cent. wrong in some cases. The "second differences" of the values of h'', with the plus value of n, seem to be constant, which appears to indicate that the function of v ought to be the second power in the formula.

If we take the mean value of m in Mr. Darrach's first experiment, and substitute in the very simple formula

$$h'' = \frac{4\, m\, L\, v^2}{2\, g\, d}$$

which is the one often used for convenience, we obtain for $v = 1{\cdot}07$, $h'' = 2{\cdot}817$, and for $v = 2{\cdot}285$, $h'' = 12{\cdot}847$ (see the fifth column in the table), which are almost as close as those of Ganguillet and Kutter's very complicated formula, and this ordinary formula cannot be excelled for simplicity.

However, let us see if we have not a very simple and more accurate formula. Weisbach gives

$$h'' = \frac{L}{2\, g\, d}\, v^2 \left(\frac{a}{\sqrt{v}} + b \right)$$

From the experiments we find the most probable values of a and b, by the method of least squares, to be $a = {\cdot}20380097$ and $b = -{\cdot}0704539$. We then obtain the values given in the third column of the table.

In this we see a much closer agreement than in the formula of Ganguillet and Kutter. When we add that the formula is also more simple, it will no doubt be conceded that for small velocities in pipes running full, the new formula is no addition to our previous knowl-

edge, but is rather in a retrograde direction. Perhaps when applied to the flow of water in open channels, its results are more to be depended on, and it is believed to have been intended by its authors only to apply to those cases. It has, however, been applied by a member of the Club to pipes, a coefficient for iron pipes having been given; and it has been specially advocated for sewers, which often flow under pressure, and are expected to do so by their designers.

For the cases experimented on by Mr. Darrach a still simpler formula, however, is found to apply. From a simple consideration of the matter, it would seem that the friction head should vary in a simple ratio to the velocity; and on plotting the values of v and h'' successively, as abscissas and ordinates, this consideration was confirmed, the points lying in a straight line, which did not, however, pass through the origin of co-ordinates. An equation of such a line was therefore assumed, $y = a\,x + b$, and by substituting the values of v and h'', the values of a and b were discovered. The final equation became

$$h'' = \frac{4\,L\,v}{2\,g\,d} \cdot 0379985 - \cdot 5394238$$

The friction heads calculated from this equation are given in the fourth column of the table.

A very close agreement is found in all the other experiments of Mr. Darrach, the value of a varying, however, from ·010026 in a 36-inch main laid seven years to ·0593879 in a 20-inch main laid eleven years. The value of b, too, varies from $-$ 9·3224583 in the same 20-inch main laid eleven years to $-$ ·5394238 in a 30-inch main laid nine years (except in one case where it was considerably more, and where its divergence from all the other values makes one think that there may have been a mistake in the experiment, which will be repeated).

It is probable that the last constant depends on the "slip" or other cause in the engine itself, and also on the resistance of the check-valves, since it is constant in the same line of pipe with all velocities. The extreme values are both given with Worthington engines. It is expected that further and more extended experiments will be carried out, after which the precise meaning of the two constants can be probably stated. If so, the Club will be promptly informed of the result.

Let us now see whether there is any force in the remark that the formula of Ganguillet and Kutter is not applicable to water flowing in pipes under pressure. It is said that an increase of pressure on the pipe would increase the friction in proportion, and as the pressure

due to the head of the water flowing in pipes not full was always small, its effect might be neglected in such pipes, while it would produce a great effect in pipes with a great head. The friction of solids on solids is proportional to the pressure, and if the same law were applicable to a fluid in a solid, no doubt an increase of head would increase the resistance. Fortunately, the experiments of Mr. Darrach furnish an opportunity for testing this. In experiment No. 5, with a static head of 167 feet, the friction head is found to vary according to the following law:

$$h'' = \frac{4\,L\,v}{2\,g\,d}\,.0175405 - 2\cdot5911932$$

where L is the length of the pipe, 20,000 feet, d is the diameter of the pipe, $2\frac{1}{2}$ feet, g is $32\frac{2}{10}$ feet and v is the velocity. In experiment No. 6, where the diameter of the pipe is the same but the length is only 4000 feet, and where the static head is 324 feet, the corresponding equation is

$$h'' = \frac{4\,L\,v}{2\,g\,d}\,\cdot0209259 + 1\cdot2018519$$

We see here that the constant depending on the velocity is only increased from ·0175 to ·0209, although the static head is nearly doubled. As regards other resistances, besides length of pipe, on which the friction depends, the shorter main had two check-valves, one quarter-turn of short radius and a "T" pipe; while the longer main had four check-valves, one quarter-turn of short radius and no "T" pipe. These experiments seem to show conclusively that the friction is proportional to the velocity and independent of the pressure of the water in the pipe.

To recapitulate the substance of the foregoing paper: Experiments show that the friction of water in pipes under pressure is independent of the static head and directly proportional to the velocity. The law is then applicable to water flowing in pipes with very small heads, such as pipes partly full. Conversely, a formula applicable to the velocity in the latter case is applicable to the former. Ganguillet and Kutter's formula applied to the former case is found wanting, therefore it is also wanting in the latter case, for which it has been so strongly recommended.

TABLE.

Formulas:

- **Weisbach.** $h'' = \frac{L}{2gd}v^2\left(\frac{a}{\sqrt{v}}+b\right)$, $v = \sqrt{\frac{2gh''d}{L\left(\frac{a}{\sqrt{v}}+b\right)}}$
- **Cleemann.** $h'' = \frac{4Lv}{2gd}a - b$, $v = \frac{2gd}{4L} \times \frac{h''+b}{a}$
- **Old Formula.** $h'' = \frac{4Lmv^2}{2gd}$, $v = \sqrt{\frac{2gh''d}{4Lm}}$
- **Kutter.** $$v = \left\{\frac{41{\cdot}66 + \frac{1{\cdot}8113}{n} + \frac{{\cdot}002807}{\left(\frac{h''}{L}\right)}}{1 + \left\{41{\cdot}66 + \frac{{\cdot}002807}{\left(\frac{h''}{L}\right)}\right\}\frac{n}{\sqrt{\frac{d}{4}}}}\right\}\sqrt{\frac{dh''}{4L}}$$

Velocity. Feet per second.	Experiment.	Weisbach. Values of h''. $a = {\cdot}20380097$, $b = -{\cdot}0704539$	Cleemann. Values of h''. $a = {\cdot}0379985$, $b = -{\cdot}5394238$	Old Formula. Values of h''. $m = {\cdot}022509$	Kutter. Values of h''. $n = +{\cdot}023$	Kutter. Values of h''. $n = -{\cdot}02635$	Values of n.
1·07	4·04	4·21	4·04	2·817	2·85	3·70	+ ·02676 and — ·02676
1·205	4·62	4·57	4·62	3·573	3·79	4·21	+ ·02565 " — ·02669
1·34	5·20	5·18	5·20	4·418	4·69	4·76	+ ·02472 " — ·02664
1·475	5·78	5·79	5·77	5·353	5·50	5·39	+ ·02387 " — ·02657
1·61	6·35	6·37	6·35	6·378	6·25	6·07	+ ·02310 " — ·02648
1·745	6·93	6·98	6·93	7·493	7·60	6·78	+ ·02241 " — ·02640
1·88	7·51	7·55	7·51	8·697	9·02	7·55	+ ·02180 " — ·02632
2·015	8·09	8·11	8·08	9·991	10·01	8·34	+ ·02127 " — ·02624
2·15	8·66	8·66	8·66	11·374	11·20	9·22	+ ·02073 " — ·02618
2·285	9·24	9·19	9·24	12·847	11·89	10·35	+ ·02021 " — ·02607

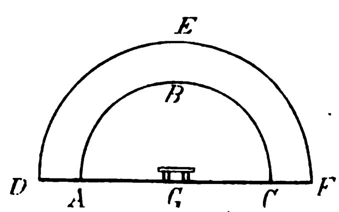
DISCUSSION ON PAPER XIV.

(continued)

Proper Amount of Water-way for Culverts[1]

By Thos. M. Cleemann, R. Hering and Chas. G. Darrach, Members of the Club.

Mr. Thos. M. Cleemann, June 7th.—Some time since a formula was brought before the Club by the writer for proportioning the size of railroad culverts from a knowledge of the drainage area. No attempt was made to deduce it analytically, as it was understood to be purely empirical, and it was asked that observations of maximum flow in streams in other parts of the country from that in which it was formed, would be made by members of the Club, in order to test its efficacy. The writer was perfectly well aware of the complicated conditions which render it impossible to deduce a rigid formula suitable for all cases. He did not, however, anticipate the objection that any algebraic expression possessed such a semblance of exactitude that members of the Club would be misled by it. Such an objection would acquire some force if the writer had been addressing a popular audience, or even a class of students, but he supposed that no member of a technical body of such standing as this, would blindly accept a formula merely out of respect to algebraic symbols, without knowing that it was empirical, and without applying it with the requisite caution. He was surprised, too, to see a formula proposed as a substitute, which is only true when the rain continues to fall over the whole area with equal violence until the flow through the culvert becomes uniform, a case never occurring except on a minute scale, as the following investigation will show:



(Major Myers) . Area of culvert $= c \times \sqrt{\text{drainage area}}$.
(Quoted by Mr. Hering)[2] " " $= c' \times$ drainage area.

[1] See pp. 146 and 149, Vol. 1. [2] See p. 155, Vol. I.

If d inches of rain fall on ABC, the amount flowing off, if none were evaporated or absorbed, would be $\frac{\pi d}{2}(AG)^2$; and the area of the culvert should be proportional to this, so that if d were doubled the area of the culvert should be doubled. If, however, the rainfall continues as at first, but the drainage area DEF is doubled, the assumption that the area of the culvert should be doubled is equivalent to saying that the rain falling on the ring $ABCFED$ would flow to the point G in the same time that it takes the rain on ABC to flow to the same point. The time of the maximum flow through the culvert of the amount which falls on $ADEFCB$ will occur *after* the maximum of that due to the fall on ABC, because it has farther to flow, and the combined maximum will occur at some time between these, and although this combined maximum is larger than the maximum of either part it is not equal to their sum, as the formula quoted by Mr. Hering assumes, but considerably less, except in the case where the rain continues to fall with the same violence over the whole of the drainage area until the combined maximum takes place, in which case the flow through the culvert would become uniform, and so continue as long as the rain continued to fall with the same violence. As a matter of fact, however, this rarely or never occurs, the water remaining at its maximum height but a very short time. The greater the drainage area, too, the less probability is there that it will rain with equal force throughout the whole of it.

The case supposed in the figure is the most favorable one for the formula quoted by Mr. Hering, the drainage area being conical, and the particles of water reaching the culvert by the shortest lines. In actual cases of main and lateral valleys it would take a much longer proportional time for the particles at the outer edge to reach the culvert, and the maximum flow would be still less than the sum of the maxima of the several parts.

Although enough has been said to show that the formula quoted by Mr. Hering is wrong in theory, it may be more satisfactory to some to show in a perfectly practical manner its utter worthlessness. To do this the formula will be tested by an actual example.

The greatest rainfall that can be expected can be discovered by previous observations. Mr. Darrach mentioned a rainfall of eight inches in an hour and a half, or five and one-third inches per hour. Dr. Draper's rain gauge in Central Park, New York, actually registered

two and six-tenths inches in twenty-five minutes, or at the rate of six and a quarter inches per hour, on August 6th, 1878. As such great rainfalls are exceptional, the very moderate amount of one inch per hour will be assumed. The culvert to which the formula will be applied is situated at the place where the Old York Road crosses the Wingohocking Creek, in the city limits of Philadelphia. A marble slab is inserted in the parapet which gives the date of its erection as 1795. As it has stood so long it is certainly proper to suppose that it has water-way enough. The area drained is 2800 acres. Applying the more general formula quoted by Mr. Hering

$$x\,y = \frac{M\,d}{v}$$

we have

$$v = \frac{2800}{x\,y}\,.$$

The area of the opening, or xy in the formula, is 265 square feet, which will give $v = 10$ feet per second. A velocity of one-half of this will move pebbles as large as an egg. The stones of the bottom to resist a velocity of 10 feet per second should contain one-half a cubic foot, according to Smeaton. Mr. Hering will perhaps be surprised to learn that as a matter of fact the bottom is only sand, and a tree is standing in the line of the arch, a few feet above its face, which would certainly have been swept away long before the water attained even a much less velocity.

The writer does not undertake to maintain the accuracy of that which has been suggested by Mr. Myers, deduced, of course, from comparatively few observations, but he will be fully rewarded if by promoting discussion he shall induce others to observe and record facts, by which possibly some data may be established, or formulas more reliable arrived at, than those which now offer themselves as guides in an important direction.

Mr. CHAS. G. DARRACH, Oct. 18th.—The formula suggested by Mr. E. T. D. Myers, of Richmond, Va., gives results singularly like the table on page 569, Trautwine's Pocket-book, the result of the 20 years experience of Mr. John Roe, London, Eng., with circular level culverts in cities, discharging the water from a rainfall of one inch per hour.

Diameter	Area of Drain.	Area of Catchment Basin.	
		Roe.	Myers, $c = 1$.
feet.	sq. feet.	acres.	acres.
4	12·5	277	156
5	19·6	570	384
6	28·2	1020	795
7	38·5	1725	1482
8	50·3	2850	2530
9	63·6	4125	4045
10	78·5	5825	6162

Mr. Hering says: "In the closely built-up sections of our Eastern cities one-half to three-quarters of the maximum fall is estimated to immediately reach the sewers; in the suburban districts from one-quarter to one-half." We may therefore assume that these sizes would, in the open country, provide drainage for a rainfall of 2 inches to 4 inches per hour.

Mr. Myers gives two coefficients: $c = 1$, for areas with easy slopes and $c = 1·6$, for areas with steep slopes.

For a drainage area of 100 acres $A = 10$ sq. feet or $A = 16$ sq. feet, equal in the first instance to a circular drain 3·6 feet in diameter and in the second to one 4·5 feet in diameter, it has been suggested that the formula is incomplete without the element of velocity. Before accepting this criticism let us study the conditions and see if this element is included.

The flood waters approaching the contracted area of the culvert rise until the head is sufficient to produce a velocity which will discharge them, if the culvert is properly proportioned, without injury to the culvert or the superincumbent bank. The surface of the water at or below the outlet becomes a minimum, as it is then free to flow down the valley and spread over the adjacent country.

Assuming that the culverts are 50 diameters long, that the head (H) is one-half the diameter, or that the hydraulic gradient is 1 in 100, then the minimum velocity, when $A = 10$, will be 6·5 feet per sec., and the discharge Q, 65 cubic feet per sec., or when $A = 16$, the velocity will be 7·2 feet and Q will be 115 cubic feet per sec., or in the equation $Q = Md$, "d" will be equal to ·65 inch, or 1·15 inches.

Myers' formula then contains the element of velocity, and is the key to the unknown value of "d".

Mr. Hering in his discussion provides for a value of d equal to one

inch per hour, or one cubic foot per sec. per acre for all areas from 1 acre to 6400 acres, and proportions his culverts to carry this amount at velocities of 2 and 5 feet per sec.

If 20 square feet at a velocity of 5 feet per sec. (table, page 156) is necessary to drain 100 acres, in order to keep down the velocity, the drain must be about 8 feet wide, and if 500 square feet is required for 2500 acres, the drain must be about 200 feet wide and 2·5 feet high, or 160 pipes 2 feet in diameter (see Hering: On flow of water. "Trans. Am. Soc. C. E.," vol. viii, No. clxxv). If the velocity is reduced to 2 feet per sec. the width becomes ridiculous. Such dimensions would force the engineer to abandon culverts and build bridges only, whereas in Myers' formula when $c = 1$, "d" (the maximum amount in cubic feet per sec. per acre reaching the culvert) will be equal to 0·65 when the area is 100 acres, 0·228 when the area is 1600 acres, and 0·2 when the area is 2500 acres.

The arch bridge built 1795, draining 2810 acres at the Old York Road and Wingohocking Creek, is semi-circular in section, with an area of 265 square feet and span of 26 feet. If it ever ran nearly full, as is stated, the water-way below it must have been obstructed, since there is no evidence of a greater velocity than 2 feet per sec. having passed through it. Had the current of water below the culvert been unobstructed, a velocity of at least 10 feet per sec. would have been developed and a scour in the unpaved water-way have been produced. The same reasoning will apply to the semi-circular arch over a branch of Tacony at Second Street Pike, built 1821, area 148 feet, draining 1600 acres.

Mr. Cleemann especially states that Myers' formula was not intended for such storms as lawyers term "acts of God," whereas Mr. Hering criticizes this formula by a criterion standing almost alone as an example of great storms, and therefore demands that the coefficient c be increased tenfold, assuming that the maximum discharge per second depends upon conditions which never occur. The facts still remain that culverts (without inverts) built under Philadelphia county roads in the beginning of the present century have withstood the storms of 1843, 1869 and 1877, nor do they give any evidence of having run full at the velocities given by Mr. Hering, although their *entire area*, not water-way, demands as a maximum a coefficient of but 4.

Mr. RUDOLPH HERING, Oct. 18th.—Mr. Cleemann, in his reply to my discussion (p. 150) thinks that the caution which I urged in using

empirical formulæ, on account of a semblance of mathematical exactness, was out of place, and "that no member of a technical body of such standing as this, would blindly accept a formula merely out of respect to algebraic symbols, without knowing that it was empirical, and without applying it with the requisite caution." The propriety of my remarks will best appear from the fact, that Mr. Cleemann himself (p. 147) has substituted values in Fanning's and Dredge's empirical formulæ, which are far outside of the range of data from which they were developed, and consequently gave those absurd results.

Mr. Cleemann then shows with the aid of a diagram that the formula $Q = M d$ is strictly only applicable to very small areas, which is nothing else than what I had stated myself (p. 152). And this fact does not in the least prove a faulty theory; for, when $t_1 > t$ (p. 152), the factor d is multiplied by the fraction $\frac{t}{t_1}$ and the formula passes into the more general forms (3) and (4).

Believing to have proved this well-known formula wrong in theory, he selects a culvert by which he also pretends to "show, in a perfectly practical manner, its utter worthlessness." An intelligent examination of the facts connected with it, however, will prove that it gives a *good* result, whereas Maj. Myers' formula gives an inadequate size. The assumption that a quantity of water corresponding to a rainfall of one inch per hour would reach the culvert from a comparatively flat, rural country of 2800 acres, which Mr. Cleemann thinks "very moderate," is unwarranted. In the afternoon of Aug. 1st, 1878, a thunderstorm passed over this city, during which 1·9 inches fell in 40 minutes. The day had been hot, and the soil was very dry. An observation made at the mouth of a long culvert in a neighboring drainage area of about 3800 acres showed a maximum section of 46·5 square feet. The velocity was ascertained to be 11 feet per second, giving a discharge of 511.5 cubic feet per second. Taking the rainfalls quoted by Mr. Cleemann, viz., 8 inches in 90 minutes, and $2\frac{5}{16}$ inches in 25 minutes, it is fair to assume about double the above discharge, or say 1000 cubic feet per second, as a possible maximum for this case. This is equivalent to a depth of rainfall $d =$ ·2632 inch per hour from about 6 square miles, which, considering the character of the area, the dryness of the soil at the time of the above observation and records at other places, is certainly not too much to provide for, yet it would be far less than 1 inch per hour.

To apply this observation to the culvert which Mr. Cleemann mentioned, we find, by considering the discharges approximately to vary as the square roots of the areas, the corresponding amount of water passing through Wingohocking Creek culvert to be about 860 cubic feet, corresponding to a depth of rainfall reaching the culvert of $d = \cdot 307$. This gives water-ways equal to 287, 215, 172 or 143 square feet, as the velocites are repectively 3, 4, 5 or 6 ft. per sec. Now the actual size of the culvert is 265 square feet, and a farmer living near the site tells me that he saw it filled to within 2 ft. of the top by a storm some 18 years ago, therefore demanding a water-way of say 200 square feet, and that several times since it had been half full, requiring a section of 130 square feet. Myers' formula gives a water-way of only 53 square feet, necessitating a velocity of over 16 feet per second. From this example I therefore fail to see that the formula $Q = Md$ is "utterly worthless," or that Myers' formula gives anything like a good result for this case.

Regarding Mr. Cleemann's statements concerning the velocity at the culvert a word must be added. I do not think any engineer would be surprised to find the bed of Wingohocking Creek to consist of sand or mud, as in ordinary times it is a sluggish stream, with a velocity of about 1 foot per second. During a flood, of course, it is increased, and the sand is washed away. Underneath, however, within one or two feet, we find coarse gravel, boulders and bed rock, showing that a velocity of even 10 feet would be possible for a short time. But, as shown, a velocity of between 4 and 5 feet was likely sufficient to convey the observed flood waters, which is also consistent with the fact that a large willow tree stands in the line of the arch. As the water section is much larger at the tree, by spreading over the meadows, the velocity will be less than in the culvert, and considering that the perimetrical velocity is less than the mean, it is not out of the way to assume it as being 3 feet at the roots. But even at a greater speed, I do not think the willow would have been swept away, on account of its tenacious roots running far into the banks, and because of the short duration of the floods in a creek.

Mr. Cleemann assumes that a rate of 1 inch per hour flowing from the area in question is a "very moderate amount." This gives a discharge at the culvert of 2800 cubic feet per second. Its water-way, according to Myers' formula, is 53 feet. To pass this amount requires a velocity of 53 feet per second, an evident absurdity. Then, either

a rainfall of 1 inch per hour for this case would be entirely too great, or Myers' formula in its application to culverts of the size in question cannot be used safely in this part of the country. The truth, as I endeavored to show, seems to lie in the middle.

Mr. Darrach's remarks next call for some comment. I cannot help expressing my surprise in finding him quote at length Mr. Roe's tables as evidence in favor of Myers' formula. To show in what estimation they are held, a passage from a letter of Mr. Julius W. Adams, written several years ago, may be of interest. "As regards Roe. No engineer in England puts the slightest confidence in his table of results. They were made to the order of the Board of Health. I have a letter on the subject from Mr. Haywood, who has for 27 years past been the chief engineer of the London Sewers Commission, which is too long to quote, in which he shows how utterly false is the statement that this table of Roe is the result of actual gaugings." It may be well to notice that these tables, as well as Bazalgette's formula, are for a rain of one inch per hour *falling*, not *flowing off*, and that they are for long sewers, not short culverts, which are essential differences.

Mr. Darrach then intends to show that Myers' formula contains the element of velocity by the astonishing theory that the diameter or depth of the culvert must be twice the head required to produce the necessary velocity, and with it calculates the depth of rainfall (d) which reaches the culvert! Were this true, then one of the missing elements which I mentioned (p. 151) as being necessary to use the formula intelligently, is supplied. Such a theory, however, is not at all self-evident from the formula, nor from the condition that the culvert shall just run full, and it demands a construction which would rarely be necessary, namely: that the *bottom* be *only* as far below the lower water level as this is below the upper. In applying this remarkable theory to the water-ways given by me in the table, he very naturally gets "ridiculous widths," and therefore condemns the water-ways. The *proper* method of determining the depth, and the one fortunately most used, is to consider the highest flood level, which is found by marks, information or estimation, as the top of the water-way, due allowance being made for back water, and the bed of the creek as the bottom (p. 157). The difference of water level above and below the culvert and the resulting velocity adjust themselves according to the difference in the shape of the water sections above and in the culvert, and to the roughness of the wetted perimeters.

To make his theory fit the case of the Wingohocking culvert, Mr. Darrach is obliged to assume that the creek below the culvert "must have been obstructed," which, by viewing the locality, seems very improbable. He then says, "there is no evidence of a greater velocity in the culvert than 2 feet." By considering that the general grade of the creek above and below the culvert is over 3 feet per 1000, causing a mean velocity of *at least* 3 feet per sec. during a flood, I think there is, on the contrary, the *best* evidence that the velocity in the contracted space of the culvert was nearer 5 feet than 2 feet per sec.

I cannot, therefore, see the consistency of Mr. Darrach's theories. He deduces indirectly from Myers' formula a value of $d = 0{\cdot}2$ for 2500 acres, or a discharge of 500 cubic feet per sec. Then, on the one hand, using the same formula, he gets a water-way of 50 square feet, which necessitates a velocity of 10 feet to discharge that amount. On the other hand, in commenting favorably on the sizes of the old culverts in Philadelphia, he does not grant even a velocity of 5 feet to have occurred in any, and in the case of Wingohocking culvert, which drains very nearly the above area, a velocity of not over 2 feet is admitted (claiming an obstruction, however), which demands that the result of Myers' formula be multiplied by *five* in order to satisfy his own value (500 cubic feet per sec.) for the discharge.

Does this not show that it is irrational or at least unwise to include the element of velocity in Myers' formula? Would it, for instance, be good engineering to build a short railroad culvert, in a very flat country, across a sluggish creek draining 2500 acres with a velocity of say 2 feet per sec., so small that it would require a velocity of 10 feet, a flow five times faster than either above or below the culvert, to discharge the flood?

Finally, I did not anticipate that Mr. Darrach would suppose from the text of my discussion that the values of v and d selected for the table (p. 156) were what I considered necessary to provide for in every case. Although they are reasonable, I do not think that, for instance, $d = 1$ for 6400 acres, would occur in our country unless the area is very steep and the surface frozen at the time the heaviest rains occur; nor, as the gist of my discussion was that Myers' coefficient depended on numerous variables, would I, without qualification, "demand it to be increased tenfold," except when the rainfall, inclination, velocity, etc., justify it.

Mr. CHAS. G. DARRACH, Nov. 15th.—Before closing the discussion on Myers' formula I wish to mention some facts gleaned from my own observation and from that of others.

During the past month Mr. Cleemann and myself measured the catchment basin, drained by a box culvert, 2 feet wide by 3 feet high, under the Reading Railroad at Perkiomen Junction, near Pauling's. The culvert was of good rubble, with a rough stone paving, and had a fall of two feet in its entire length of 107 feet. It was built in 1836, drained 90 acres, carried the maximum flood until Oct. 4, 1877, and during a period of 40 years was sufficiently large to carry all the water reaching it. During the storm of Oct. 4, 1877, the embankment above it was destroyed. The water was forced up between the covering stones by the head of water in the dam, which had accumulated behind the bank and above the top of the culvert.

The culvert in question, having but six square feet of water-way, seems to have been just too small. Myers' formula would have made it 9½ square feet, which in all probability would have been sufficient even for a storm which is without a precedent in the Schuylkill Valley. Comparing it with the storm of 1869, we find that at Phœnixville, 2½ miles distant, Oct 4, 1869, 7 inches fell. Oct. 4, 1877, 3 inches fell in about 1½ hours. Mr. Jas. F. Smith, Consulting Engineer Reading Railroad Canals, writes to me as follows: "The flood of 1869 was of such a character at almost every dam below the mountain as to preclude any measurements; some of the dams, such as Pauling's, were drowned out, and at others the water passed around the abutments."

In regard to the flood of 1877, he says:

"On that occasion the rise was very limited *above* Phœnixville, but at that point was sudden, and so also at Pauling's and Catfish dams, and other dams quite to Flat Rock. The rise at Port Kennedy, one mile above Catfish dam, came suddenly and surprised boatmen who were not prepared. The rise was ten feet, and boats, scows, etc., were landed on the tow-path and in the fields."

This storm, although not general in the Schuylkill Valley, raised the water on Fairmount dam 7½ feet, being higher than any other recorded flood except the great storm of Oct. 4, 1869, when it was 11½ feet.

The general application of Myers' formula, as suggested by Mr. Cleemann for bridges, *i. e.*, for large drainage areas, forces us to study

it and attempt to discover the natural theory (if one there be) applicable to this empirical formula.

From the experience of Mr. Myers we find that the maximum flow is proportional to the square root of the drainage area $\sqrt{M}$, and not proportional to the average breadth of the drainage area, $\frac{M}{L}$ as suggested in Mr. Hering's formula, $Q = \frac{D M r}{L}$, nor will this or any other formula determine the maximum flow when it is occasioned by the melting of ice or snow, which we must infer from Mr. Hering's remarks.

Introducing the factor of velocity into Myers' formula, we obtain the quantity $Q = v \times c \sqrt{M}$, in contradiction to $Q = D \times \frac{M}{L} \times v$; calling $v \times c = c'$, $Q = c' \sqrt{M}$.

Inasmuch as the maximum rain storms vary in different countries, it is not possible to frame a formula in which the value of the coefficient or modulus will be constant, and at the same time universal in its application.

The values of c and c' depend upon the geographical, topographical and geological features of the catchment basin as well as upon the amount of the storm or storms that reach the culvert or bridge in a given time.

When the other conditions are the same; in small areas the maximum discharge will depend upon a proportion of the direct down-pour per unit of time; in larger areas upon a part or the whole of a storm or series of storms.

Mr. Myers' experience in Virginia gives for small areas $c = 1$, or $1\frac{6}{10}$, which seems to apply as well to Pennsylvania. Introducing $v = 10$ in paved culverts; $c' = 10$ or 16.

For areas drained by creeks or small rivers in which the maximum discharge occurs before the storm ends; the coefficient c will vary in this country and Europe from 2 to 8, proportional to the drainage area.

For large rivers in the United States and Continental Europe the value of c may be taken as 10 and c' as 60,[1] derived from the following table of the greatest recorded floods from the given drainage areas, excepting the river Loire, in which the great flood was no doubt caused by melting snow.

[1] In East India maximum $c = 50$, $c' = 300$.

RIVERS.	Drainage Area, M acres.	Water-way, $A = c\sqrt{M}$ sq. ft.	v.	c.	c'.	Discharge.—Cub. ft. per sec. Total, $Q = c'\sqrt{M}$	Discharge.—Cub. ft. per sec. Per acre, $d = \frac{c}{\sqrt{M}}$
Mississippi at Red River Landing	796,160,000	270,000 282.160	 6	9·3 10	 60	 1,692,960	 0·00212
Mississippi at Columbus, Ky.	576,640,000	164,400 240,133	8·53 6	6·8+ 10	58 60	1,403,000 1,440,798	0·0024 0·0025
Danube, Europe	192,000,000	 140,000	 6	 10	71 60	1,000,000 840,000	0·0051 0·0044
Ohio at Mouth	136,960,000	168,000 117,000	4·2 6	14·3 10	60·3 60	700,000 702,000	0·0051 0·0051
Mississippi	108,160,000	100,000 104,000	 6	9·6 10	 60	 624,000	 0·0058
Red River	62,080,000	79,700 78,790	 6	10·1 10	 60	 472,740	 0·0076
Danube, Europe	46,700,000	 68,340	 6	 10	79 60	540,000 409,040	0·0115 0·0089
Ohio at Wheeling	14,720,000	50,000 38.366	4 6	13 10	53 60	200,000 230,000	0·0136 0·0156
Rhone, France	11,520,000	 34.000	 6	 10	60 60	202,500 204 000	0·0177 0·0177
Rhine	10,240,000	 32,000	 6	 10	51 60	164,700 192.000	0·0160 0·0189
Connecticut	6,500,000	 25.500	 6	 10	81 60	208,000 153,000	0·0320 0·0235
Delaware	5,100,000	23,570 22,360	 6	10·5 10	 60	 134.160	 0·0263
Lot	3,840,000	 19,600	 6	 10	59·5 60	116,640 117.600	0·0303 0·0307
Merrimack	2,650,000	 16,280	 6	 10	60·2 60	98,150 97,680	0·0370 0·0369
Loire, France	1,408,000	 11,866	 6	 10	209 60	248,400 71,196	0·177 0·0506
Schuylkill, Philadelphia	1,216,000	12,650 11,030	 6	11·5 10	 60	70,000 66 180	0·0575 0·0544
Schuylkill at Pauling's	1,000,000	10,000 10,000	 6	10 10	 60	 60,000	 0·0600
Croton, New York	217,000	[1]12,295 4,658	11½ 6	 10	54 60	25,390 27,948	0·117 0·128
Passaic, New York	128,000	 3,577	 6	 10	50 60	18,000 21,642	0·140 0·168
Nashua, Mass.	70,400	 2,653	 6	 10	43 60	11,394 15,918	0·162 0·226
Woodhead, Eng.	7,040	 840	 6	 10	42 60	3,512 5,040	0·500 0·700

[1] Weir.

The velocity of the flood current with this size water-way is calculated to be 6 feet per sec., or 4 miles per hour[1]; the table shows a few cases in which it may rise higher, in one case to 8 feet per sec., 5½ miles per hour.

From this table we find that the value of d, the flood discharge per sec. per unit of drainage area, is inversely proportional to the square root of the drainage area. (Diagrams shown with d, Q and A plotted.)

The application of this form of equation to determine the flood discharge is not, however new, as the formula of Dickens, reduced to the same notation becomes $Q = c' \times 1{\cdot}07 \sqrt{M}$, and in the Proceedings of the Institution of Civil Engineers, London, vol. xxvii. in a paper by Lieut. Col. P. P. Lyons O'Connell, R.E., diagrams and the formula $y = M \sqrt{x}$ are given, in which y = discharge in cubic yards per sec., x = the drainage area in square miles, and M the modulus of the stream; in order to make the equation apply to smaller streams, he says:

"For the sake of illustration it will be assumed that a district exists in which the maximum rate of rainfall is 5 inches an hour, and the maximum value of the modulus M is 20. This requires that the origin of co-ordinates be situated at a point in the parabola where its geometrical tangent is inclined to the axis of x at an angle whose trigonometrical tangent is 120. If x' and y' be the rectangular co-ordinates of the curve measured from this point, its equation is $y' = 20 \sqrt{x' - \frac{y'}{120}}$; the areas being measured in square miles and the discharge in cubic yards per second. But, as for small areas it will be more convenient to measure the areas in acres and the discharge in cubic feet per sec., the formula becomes, when adapted to these new measurements:

$$y' = 21{\cdot}4 \sqrt{x' - \frac{y'}{5}}$$

very nearly, or, after the solution of this quadratic equation:

$$y' = -15{\cdot}796 + \sqrt{209{\cdot}728 + 15{\cdot}796 x'}"$$

Reducing Col. O'Connell's original equation to the same notation as Mr. Myers', the comparison is as follows:

Myers, $Q = c \sqrt{M}$
Dickens, $Q = c \times 1{\cdot}07 \sqrt{M}$
O'Connell, $Q = c \times 0{\cdot}9 \sqrt{M}$

[1] Tide at Philadelphia runs at 3 miles per hour.

RUDOLPH HERING, Nov. 15th.—Mr. Darrach, by insinuating the incorrectness of the formula $Q = D\frac{M}{L}v$, given p. 152, shows evidently that he has not examined it. I will therefore review its theory, and in connection therewith, as he has enlarged upon river floods in general, give the results of some studies I made on the same subject.

By a little reflection it will be evident that the maximum amount of water (Q) that can reach the lowest point of a drainage area at any one second is equivalent to a body having the following three dimensions:

d = the average depth of rain flowing off the surface per second.

s = the average distance which a particle of water flows during the entire storm, from the average slope and measured along the flow line. For, as the average unit of area receives every second not only the amount of rain that is falling on it but also the water that is running on it from the units above, the maximum amount passing the lowest per second will, if v is the distance the water flows per second and t the duration of the rain, come from $v\,t$ units, which is equivalent to the average distance that one particle flows during the entire storm, or s.

b = the average breadth of the widest portion (of the *rain* area), having a length s and measured on a curved line intersecting the lines of flow at right angles. For it will be evident that the water from all units of area, which are equally far from the lowest point, will reach it at the same time, supposing, of course, uniformity of slope and surface. Then the maximum amount discharged at any one second will come from the greatest possible number of equidistant units, which themselves pass the greatest amount of water, $v\,t$ or s. This will be from an area having s for its length and b, as defined before, for its breadth.

Therefore,

$$Q = d\,.\,s\,.\,b \qquad (1)$$

For obvious reasons, s can never exceed the length of the *drainage area* nor b its breadth, measured as above. This equation is strictly true as far as a product of averages can be.

That Q is thus proportional to the greatest breadth will be quite clearly seen by examining two sectors of equal area but with different radii. If the rain should last but a moment, the maximum discharge at the vertices varies directly, as the arcs or the widths, but not as the areas, as Mr. Darrach affirms. The longer the rain lasts the less will

[illegible] until, when s = the radii [illegible] constant and equal. Q then varies [illegible]

$$= \quad [illegible] \tag{2}$$

[illegible] area divided by the length [illegible] breadth of the entire area instead of [illegible] have the formula which Mr. [illegible] However, I think it will now be [illegible] with the breadth, as shown [illegible] area, except where these [illegible]

[illegible] Mr. Darrach's discussion it [illegible] this formula a little further. For dt, [illegible] flowing off during the entire storm, we [illegible] depth of the rainfall upon the [illegible] not absorbed, retained or evap[illegible] average slope and ζ a coeffi[illegible] ground, we may writ[illegible] Then [illegible]

$$Q = [illegible] \tag{3}$$

[illegible] of a flood discharge. [illegible] then b applies to the latte[illegible] length of the drainage area, then $Q = M\,d$, as shown pa[illegible]

Comparing the formulæ of O'Connell and Dickens with equation ([illegible] find that their value $\sqrt{M}$ represents our b, and their modulus c' our product ds or $f\,r\,\zeta\,\sqrt{2g\sin.\,a}$. The $\sqrt{M}$, then, is merely a co[illegible]venient approximation, as we have seen, and will be the more corre[illegible] the less difference there is between the length and breadth of the are[illegible] Regarding c', it will be noticed, from Mr. Cleemann's as well [illegible] Mr. Darrach's table, that its values are nearly constant for the actu[illegible] flood discharges from over 200 square miles. This fact will find i[illegible] explanation by considering that our value for it, ds, is the amount [illegible] water from a strip of ground whose width is unity and whose leng[illegible] is s or vt. We can then readily see, as the extent of the storm

independent of the drainage area, that this amount must generally be about the same for all areas in which the water from the highest points does not reach the lowest before the storm ceases, which will be the case in areas over say 200 square miles, providing the climate and general topography are the same.

Therefore the formula $Q = c' \sqrt{M}$, with a constant coefficient, is theoretically justified as a rough approximation for large areas. Mr. Darrach selects $c' = 60$ if the areas are acres, which answers well. According to the above reasoning, this coefficient must decrease for small areas, and, in order to reconcile Myers' formula with this one, he selects a coefficient of 50 to 20 for creeks and small rivers and 10 or 16 for paved culverts. But a coefficient that varies from 10 to 60 without further guidance is certainly not satisfactory. If it varies with the area, as might appear to be the case, and if we take for a maximum an area of 200 square miles, and let c' denote 10 or 16, according to the steepness of slope, as he has proposed, then Myers' formula would become:

$$Q = \left(c' + \frac{\sqrt{M}}{8}\right) \sqrt{M} \qquad (4)$$

which would answer much better than the wide range of coefficients. But even this would be as irrational as they are, when we get below 100 acres, showing again that the function is wrong.

In studying the question of flood discharges, primarily with reference to large sewers, it was my desire to obtain a more rational formula than those in use at present, and equation (3) was the result. Being pertinent to the matter under discussion, I will add a few words concerning it.

The paper of Lieut.-Col. O'Connell, quoted by Mr. Darrach, was followed by a lengthy and interesting discussion on the formula he had proposed. Mr. J. T. Smith remarks:[1] "It has been well said that the modulus (c') was too wide and comprehensive to be of much use. In order to make it useful, it must be taken, split into parts and each part valued." And he mentions as such, the relation of the area of rainfall to the drainage area, the structure and general character of the surface, the amount and continuance of the rain and the general form and slope of the basin. "If these points were attended to, it would be possible to ascertain something like a fairly correct though rough

[1] "Proc. Inst. Civ. Engs.," vol. xxvii, p. 240.

estimate of the maximum flood, and that was all the engineer wanted." Mr. Beardmore suggests that the sine of the angle of the general slope of the country should form an element in the formula for the discharge.

Now, it will be noticed that equation (3) contains all the elements which are here mentioned as being necessary, and which are wanting in O'Connell's formula. I therefore consider it worth a closer examination. Of course, without values for the coefficients, it can be of very little use at present, but it shows in what direction data should be collected.

Instead of one coefficient, there are three which must be known, namely:

1. r, the entire average depth of rain that falls upon the area during the storm, or of water formed by melting snow or ice.

2. f, a fraction indicating what proportion of this water actually runs off.

3. ς, the coefficient of resistance of the water flowing off.

At first sight it may appear difficult to find proper values for them, but a little inquiry will, to a great extent, dissipate any fear.

It would lead too far in the present discussion to examine how each one might be found. I will merely observe that r varies indirectly with the size of the area, and can be properly determined only from rain-gauge observations at numerous points not far apart, or that it varies directly with the temperature when the ground is covered with snow and ice, and that f and ς, being independent of the size of the area, can be obtained from quite small areas, convenient for experiment. It would be necessary, in the case of f and ς, to adopt a scale, each point corresponding to certain physical features to be indicated thereby. All existing flood records, provided the proper elements could be obtained, would likewise be useful in determining some of the values of these coefficients.

As progress in engineering science consists mainly in more completely analyzing forces and their actions, and in studying more thoroughly into details, why should we not strive to advance also in this direction and endeavor to discriminate more properly between the different causes affecting a flood discharge?

Until we have more observations on the values for these three coefficients, it is of course necessary to use less accurate means for determining these discharges. For large areas the formula of Dickens with

Mr. Clemann's coefficient and the formula of O'Connell with Mr. Darrach's coefficient, the latter giving greater discharges than the former, are very simple and convenient. For small areas, however, there are no reliable approximations, and also very few records of flood discharges. Desiring to obtain some light in the matter, I plotted some time ago the available records to see whether a probable curve could not be found. Commencing at zero, such a curve would have to start in the direction of a line indicating the maximum rainfall per sec. on a very small area, which would be one condition. As all the coefficients will converge toward those of the largest basin, it is safe to terminate all the curves at or near the greatest flood discharge of the Mississippi, which would be another condition. A third one will be found by examining intermediate discharges, and the fourth is the condition for the zero point. I have drawn several of such curves (parabolas) starting with various rates of rainfall, and all terminating near the discharge of the Mississippi (diagrams shown). It will be seen that they answer well as approximations for the actual cases, and it is therefore at least probable that they will also apply to the intermediate ones. The general equation of the curves is

$$Q = a\sqrt{M + b} \pm e\,M - d \qquad (5)$$

in which Q is the discharge, M the drainage area, a the square root of double the parameter, b the abscissa and d the ordinate of the zero point with reference to the apex of the parabola, and e the tangent of the angle which the axis of abscissas for the Ms forms with that of the parabola.

This equation, with a slight modification, might be made to include the condition that for very small areas the discharge varies directly as the area. To enter into this would lead too far at present.

For M as square miles and acres, and Q as cubic feet per sec., the following are the values for three of these curves. A closer study in connection with new observations may, of course, modify them somewhat. In order to have round numbers as much as possible, the rainfalls were not assumed as regular fractions, nor will the values for acres and miles correspond exactly, which is not at all necessary in formulas for approximations:

1. For flat, rural countries; the maximum rain flowing off of a very small area being assumed at about ½ inch per hour:

Square miles, $Q = 1300\sqrt{M + 4} - 2600 + 0{\cdot}2\,M$ (6)

Acres, $Q = 50\sqrt{M + 2500} - 2500 + 0{\cdot}00037\,M$

2. For hilly countries; the maximum rain flowing off of a very small area being assumed at about 1 inch per hour:

Square miles, $Q = 1700\sqrt{M + 1{\cdot}68} - 2200 - 0{\cdot}1\,M$ (7)

Acres, $Q = 65\sqrt{M + 1142} - 2200 - 0{\cdot}0001\,M$

3. For *very* favorable conditions for a flood, such as a sudden and heavy thaw, steep slopes and ground well saturated, frozen or paved: the maximum rain flowing off of a very small area being assumed at about $1\frac{1}{2}$ inches per hour:

Square miles, $Q = 2100\sqrt{M + 1} - 2100 - 0{\cdot}5\,M$ (8)

Acres, $Q = 83\sqrt{M + 640} - 2100 - 0{\cdot}00078\,M$

These equations may yet be simplified by considering that for large areas we may neglect b and for small areas c, because they are then comparatively insignificant. Not being distinct classes, but simply three convenient positions in a continuous range of increasing coefficients, we can modify the results by interpolation to suit intermediate amounts of rain flowing off or variations of any of the other conditions.

Naturally, these formulæ should be taken as mere rough approximations, but they have the advantage of being at least as correct as any others, besides covering the range of *all* areas from the Mississippi basin to one acre. They agree well with all published flood records,[1] except those of the Loire, which appears to have had quite a phenomenal flood, and the East India rivers during the wet season, when they discharge rains of extraordinary magnitude.

Such cases as these, however, would have their flood discharges fairly represented by equation (3), in which values for the heavy rainfalls peculiar to the East Indies can be substituted, as coefficient r, the other coefficients, f and ς, remaining about the same as elsewhere.

Before closing this somewhat lengthy discussion, let it be urged that engineers who have the opportunity should endeavor to collect data, not merely for the simple flood discharges of a stream, but also for the values of the factors which are so essential in modifying them, for

[1] Nearly all of the records given in the table, p. 205, show values falling between those of formulas (6) and (7), as should be expected. Only the Danube and the Connecticut are represented by formula (8).

such knowledge will not only serve as a guide for the maximum water-way of a stream, but it will also in time render it possible to predict, during a rainstorm or as it ceases, the height to which the river draining it will probably rise, which at some seasons, if not always, would be of great value to navigation and commerce.

Mr. DARRACH, Nov. 15th.—We cannot assume from the meagre facts used by Mr. Hering that his formulæ, although containing as an element $\sqrt{\text{area}}$, are applicable to all areas of whatever magnitude.

From his own observation of a discharge from an area of 3800 acres during a rainfall of 1·9 inches in 40 minutes, or at the rate of 2·85 inches per hour, the value of d was ·1346. From the formula $d = \frac{10}{\sqrt{M}}$, deduced from Mr. Myers' experience, for an area of 3800 acres, $d = {\cdot}1623$. Mr. Hering, however, assumes from the exceptional rains at the rate of 5·7 inches per hour, noted by Mr. Cleemann, that the value of d would become ·2632 as a possible maximum, whereas from equation (6) (p. 155) the value of d is ·3868.

The experience of Mr. Bazalgette suggested the formula

log. of diam. of sewer in inches $= \frac{3 \log. A + \log. N + 6{\cdot}8}{10}$ in which

A = area of catchment basin in acres;

N = length in feet, in which the sewer falls one foot.

This formula gives results almost identical with Roe's tables, approved by Hawksley, Bidder and Kirkwood for rains of one inch per hour in cities.

Assuming that the grade of the culvert is 2 inches in 100 feet (almost level), by this formula a circular sewer of

a diam. of	4,	5,	6,	7,	8,	9,	10 feet
will drain	258,	543,	996,	1665,	2599,	3849,	5547 acres.

which dimensions agree closely with the comparisons of Roe and Myers (p. 197).

Mr. THOS. M. CLEEMANN, Nov. 15th.—In the storm of August 6th, 1878, in New York, $2\frac{67}{100}$ inches fell in twenty-five minutes. If 20 per cent. soaked in or was evaporated, it would leave 2 inches remaining on the ground or flowing off in the time of the rainfall. If a quarter of an inch an hour is sufficient to take as the amount flowing

off, one-eighth of an inch is sufficient to take as flowing off in twenty-five minutes; therefore, at the end of the storm, 1⅞ inches should have remained standing over the whole surface on which this rain fell. If this extraordinary spectacle had occurred it certainly would have been noted. If a less amount remained on the hills of Central Park, say even one-half an inch, which seems a large amount to the writer, the remaining 1⅜ inches would inevitably have found its way to the water courses and have raised them very much beyond the amount that would be produced by one-quarter of an inch per hour flowing off.

The illustration of the tree standing near the axis of the water-way of the culvert on the Old York Road seems to require more development to make its lessons clear. It is growing on material which has been washed down by previous storms and which consists of sand and alluvium, which would certainly be washed away if the stream attained a velocity of 1 foot per sec. It stands at a distance of 18 feet from the face of the culvert and 4 feet from its axis. The tree measures one foot ten inches in diameter. It is a willow which grows rapidly, but it is probably much within the mark to say that it would take 40 years for even a willow to attain that size. This interval of time would include the great storms of 1843, 1869 and 1877, and the proof seems complete that the velocity did not exceed in either of those years the maximum of one foot per sec.

According to the formula quoted by Mr. Hering and numbered (7), p. 155, even taking his own rainfall of one-quarter of an inch per hour, it should have equaled $2\frac{85}{100}$ feet per sec. It is confidently left to the judgment of engineers whether the said formula is a trustworthy one to be used in designing culverts.

The writer admits the great velocity of 53 feet per sec. at Wingohocking Creek culvert if the rain continued to fall over the whole drainage area at the rate of one inch per hour until the particles at the extreme limit had time to reach the culvert. He said in his previous discussion that the formula quoted by Mr. Hering was correct for this case in the following words: "A formula which is only true when the rain continues to fall over the whole area with equal violence until the flow through the culvert becomes uniform, a case never occurring except on a minute scale." Mr. Hering's *reductio ad absurdum* is due to the fact that he uses his own formula for the discharge (the depth flowing off multiplied by the whole area). The results are what were to be expected from the formula. The amount flowing off and the

velocity at the culvert are each of them variable and uncertain, and the introduction of two unknown quantities does not advance us in our search for the proper water-way.

XIX.

PROGRESS OF THE GEODETIC SURVEY OF PENNA.

By Prof. L. M. HAUPT, C.E., Member of the Club.

Read November 1st, 1879.

The computations of this season's work on the geodesy of Pennsylvania being completed, I thought it might prove interesting and valuable to the Club to present a synopsis of operations, and to place the results on record in our archives, in permanent form, as a matter of reference.

The inception of the survey was the result of a conversation held in 1874 between the Hon. C. P. Patterson, Supt. U. S. C. & G. Survey, under whose direction the work is conducted, and Prof. J. Peter Lesley, Director Second Geological Survey of Pennsylvania. It was organized under an act of Congress of March 3, 1871, making an appropriation "For extending the triangulation of the Coast Survey so as to form a geodetic connection between the Atlantic and Pacific coasts of the United States, including compensation of the civilians engaged in the work; provided that the triangulation shall determine points in each State of the Union which shall make requisite provision for its own topographical or geological surveys."

Having had the honor to be selected to conduct the work in this State, I began operations, at Prof. Lesley's request, by a reconnaissance in Lehigh and Northampton counties, on July 1, 1875, with the expectation of connecting with a known line on the U. S. Coast Survey system through New Jersey, by uniting with the recent work in that State under Prof. Bowser.

As he was required to operate in a locality non-adjacent to our system, and as there was no ground suitable for a base line in the vicinity of our work, we found it necessary to select another portion of the coast chain from which to start the triangulation. For this purpose a description of the four points, Meeting House Hill, in Delaware, and Principio, Finlay and Osbourn's Ruin, in Maryland, was obtained from the records in the U. S. Coast Survey office, and Messrs. B. F.

Warren and J. W. Van Osten, Jr., sent to examine them, with a view to an extension northwardly.

Just here let me call attention to the manner of conducting the reconnaissance, as I believe it due to this plan of operations that we succeeded in making this connection where previous efforts had failed.

Equipped with a small "Casella" prismatic compass and field glass, a party of two proceed to the neighborhood to be examined, which may be indicated approximately by the water-shed lines of any available maps.

Arriving at the site, the highest point (*P*) is sought for, requiring considerable judgment, and, in undulating country, heavily timbered, much walking and climbing of trees.

Having found a point (*P*) supposed to answer, bearings are taken from the tops of the trees, which generally cover the summits occupied to any and all conspicuous objects, noting especially the most distant faint blue points, and the sectors in which they appear. If any sectors of the distant horizon be obscured by near hills, trees or other objects, tangents should be read to them and their approximate distances, obtained by estimation, as well as the bearings of the lines tangent to them, should be recorded by the aid.

An outline sketch of the horizon should also be made when possible, and will be found of great assistance in selecting the proper points and determining the intervisibility of the several apices of the system. This may be drawn upon paper ruled so that the horizontal distances between any two of a series of parallel vertical lines may represent any convenient number of degrees of the horizon as, 5° or 10° to 1 inch.

The bearings obtained should next be platted on tracing paper, when, if the position of any three of the objects sighted to is laid down on the map, the point occupied may be rapidly determined by the three-point problem, and the bearings to the remote distant points which may be suitable for new stations can be determined. If the distance to any one, say (*R*), be approximately known, and it be found that a number of streams head at or near that point of the map, and diverge therefrom, it is probable that the point thus determined is high and will answer, if visible from other adjacent stations. Should the same point (*R*) lie in a distant open sector from either of the stations adjacent to (*P*) as (*Q*) or (*O*), it is still more probable that it will answer, and if on visiting the point (*R*) it be found that the

reverse bearings to (P) and (Q) lie in open sectors, it is reasonably certain that the signals at these points will be mutually visible.

To return to the application of the above principles: The examinations at Osbourn's Ruin, Finlay and Principio revealed the fact that there were no distant open sectors to the northward which would intersect, but at Principio and Meeting House Hill there was a possible chance along the water-shed running northward through Chester county from Penn Station, on the P. & B. C. Railroad, to Parkesburg, on the Penna. Railroad.

After an exhaustive search for five days in a circle of about three miles radius, and the climbing of numerous tall trees on the line towards Meeting House Hill, a point was at length found near Londonderry from which it was thought the hill at Principio, 19 miles distant, might be visible, as well as a point to the westward, which could also be seen from Principio. As the connection was therefore reasonably certain, the reconnaissance was continued westwardly along the southern part of the State to Huntingdon and Bedford counties, when the appropriation being exhausted, June 30, and there having been no provision made by Congress for continuing, work was suspended for one year.

In resuming operations at Londonderry in June of 1878, the trees were in full leaf, and a woods of tall timber, about half a mile distant, intercepted the view in the direction of Principio. It was therefore necessary to erect a station, 71 feet high, to keg on signal pole, at the first-named point, and to try heliotroping and night signals. For this latter purpose, special port fires, two feet long, were ordered. These, tied upon poles, were held aloft from the tops of the tallest trees on the hill at Principio, but were invisible from the platform of the tripod at Londonderry. It was necessary to get higher to know just where to open the line through the woods near Londonderry, as the owner was opposed to any cutting, and asked heavy damages. Flying machines were not available—ballooning was too expensive, and the trees were too short; the best solution of the problem to elevate myself at little expense was to borrow ladders from Charlestown, three miles distant, splice them together and raise over the site. This was accordingly done, and was quite successful, as a port fire burned from the top of this ladder, 60 feet high, at 10 P.M., June 14, 1878, was seen from the apex of the tripod, at Londonderry, through the tops of the obstructing trees, and gave the required direction. The line

was marked by a stake, and ranged through to the woods next morning, thus rendering certain the much-desired and only possible link necessary to complete this connection. To see over the hills towards Rawlinsville, a station was built at Principio 60 feet high, and others at Meeting House Hill and Rawlinsville, and the work of reading horizontal angles begun.

The instrument used was a 10-inch Gambey theodolite, graduated to 3 seconds.

The objects observed upon were either signal kegs, apices of tripods, or heliotropes, the latter being preferable, as they can be seen through a dense haze when outlines of mountains are invisible.

To determine the magnitude of an angle with sufficient accuracy, a large number of repetitions are made on various parts of the graduated circle or limb, and with the telescope both direct and reversed. The effect of this is to eliminate, so far as practicable, instrumental and personal errors, such as those of defective graduation, eccentricity, collimation, level, inaccurate reading and pointing, and atmospheric disturbances.

Usually, 6 sets of 6 repetitions each are made, 3 being direct and 3 reversed, making 36 repetitions in all, but it sometimes happens that 15 or more sets are necessary before reducing the probable error to the desired limit, 0·7 sec. This may happen when the line of sight passes close to the summits of intervening ridges, or over furnaces or towns, causing local disturbances.

The sum of the spherical angles thus obtained at each station should not differ from 360° by more than 3 or 4 seconds, for good work. The station error, whatever it may be, must be distributed by the principle of least squares, and the resulting angles of any one of the spherical triangles corrected for spherical excess, and thus reduced to plane triangles, the sides of which are then computed and the geodetic positions of the apices determined.

During the season of 1878 the two triangles, Meeting House Hill, Principio, Londonderry, and Principio, Londonderry, Rawlinsville, were completed, and this year three more were added to the list, covering Lancaster county and part of Chester, Berks and Lebanon.

There were over 3000 pointings made during this season, and 24 horizontal angles read. The positions of the points as determined are appended for reference:

U. S. COAST SURVEY. GEOGRAPHICAL POSITIONS.—SECTION II.—LEWIS M. HAUPT *in charge.*

B. F. WARREN, J. W. VAN OSTEN, JR., *Aids.* LOCALITY, *Pennsylvania.* SKETCH *No.* .

NAME OF STATION.	LATITUDE. Deg.	Min.	Sec.	LONGITUDE. Deg.	Min.	Sec.	AZIMUTH. Deg.	Min.	Sec.	BACK AZIMUTH. Deg.	Min.	Sec.	TO STATION.	DISTANCE. Meters.	LOGARITHMS.
							South being 0°.								
Principio..................	39	35	34·037	76	00	18·082									
Meeting House Hill...	39	42	43·666	75	42	41·652	62	20	39·978	242	09	25·839	Principio...........	28455·066	4·4541596
Londonderry............	39	51	47·936	75	52	52·05	19	30	52·698	199	26	07·621	Principio...........	31855·771	4·5031884
							319	04	45·183	139	11	15·805	Meet'g House Hill	22194·731	4·3462499
Rawlinsville............	39	53	06·979	76	16	00·150	325	16	55·593	145	26	57·857	Principio...........	39463·833	4·5961998
							274	06	11·259	94	21	01·178	Londonderry........	33072·830	4·5194715
Beartown.................	40	04	49·441	76	00	50·152	44	58	54·569	224	49	09·843	Rawlinsville........	30583·734	4·4854905
							334	45	03·130	154	50	10·277	Londonderry........	26637·5012	4·4254935
Womelsdorf.............	40	19	25·808	76	11	46·397	7	03	31·242	187	00	47·768	Rawlinsville........	49060·6404	4·6907332
							330	04	40·143	150	11	43·740	Beartown............	31166·001	4·4936811
Black Spot (Reading)	40	20	48·690	75	54	11·473	84	13	58·543	264	02	35·733	Womelsdorf.........	25028·4321	4·3984336
							17	44	32·305	197	38	14·901	Beartown............	31049·1580	4·4920528

These results show by comparison that all the above points, as located on maps now extant, are from one to two miles out of their true geodetic position.

My letter of July 25th, 1879, published in the "New Era," of Lancaster county, gives a popular idea of the work and its accessories.

XX.

AN IMPORTANT LEGAL DECISION.

By P. Roberts, Jr., Member of the Club.

Read November 15th, 1879.

During the past month a case has been decided in the U. S. Circuit Court, in this city, in which suit was brought to recover damages upon a lot of structural iron furnished by plaintiff to defendant, who refused to settle the original account by an amount equal to expenses incurred in rendering said material suitable for intended use. Judge McKennan's charge to the jury cannot fail to be of great interest and importance, not only to engineers and manufacturers, but to all parties connected with transactions in constructive materials. It is the object of this paper not to criticize the rulings of the Court, for the old adage of the cobbler and his last is still applicable, but to make a few suggestions as to the results arising from this decision, which in future will, no doubt, be cited as of much importance in legal disputes.

The history of the case, quoted from the *Iron Age* of October 23d, is briefly somewhat as follows:

"It appears that in May, 1878, the Edgemoor Iron Company, of Wilmington, Del., made a verbal contract with the Atkins Bro's, of Pottsville, Pa., for angles, to be used in the construction of one of the elevated railroads of this city (New York). The work, when erected, was condemned by the inspectors as not up to requirements in quality of iron. The Edgemoor Iron Company were forced to strengthen the parts of the structure containing the defective material at their own expense, and in their turn refused to pay Messrs. Atkins Bro's more on their contract than a sum representing the difference between the original contract price and the cost of the repairs made. Messrs. Atkins Bro's sued for the amount of their bill."

Judge McKennan's charge, which is a lengthy one, I will not quote in full, but merely give some of the more important points:

"But there is another ground, as I understand, upon which the defendants rest their right to damages for alleged non-compliance with the contract by the plaintiffs. They claim that even if there was no such express agreement as I have referred to, still under all the circumstances there was an implied obligation on the part of the plaintiffs to furnish such iron as was suitable to be used in these structures. Undoubtedly the counsel for the plaintiffs have stated the rule of law correctly as a general rule; that is to say, that where the subject of a contract of bargain and sale is an existing article, and it is there, the rule of *caveat emptor* applies. There is no implied warrant of quality in such case. But where the subject matter of the contract is a thing not in existence—where it is an article to be manufactured by the seller—and he is informed at the time of the contract that it is intended for use in a special way—that it is intended for a special purpose—then the law does imply a warranty by the seller that the thing so furnished shall be reasonably fit for such purposes, or in other words, where a special purpose is explained and stated, that it shall be fitted for such special purpose. That has reference not only to the form, but to the quality of the thing to be furnished. It is alleged here that the circumstances under which this contract was made were such that an obligation of that kind was assumed by the plaintiffs. You will perhaps agree with the defendants' counsel as to that aspect of the case. There is no doubt about the fact that this iron was to be used in a structure of a particular character; that it was a particular kind of iron, and that certain qualities were essential to the value of it in such use. It will hardly be said that a man who was making a contract for angle iron of certain dimensions, and was told that it was to be used in a particular construction, such as this, for instance—over which it was to bear heavy weights; over which locomotives and passenger trains were to be carried—it would hardly be fair to assume that the parties intended that iron which would be suitable for use in a bridge over which people were to walk merely, was intended. Therefore, it is that the rule which I have stated is founded upon sound common sense; that where parties come together and make a contract in reference to a particular thing, and they both understand that it is intended for a particular use, that something which is not at all adapted to that use is not to be supposed to have been the subject

of the contract between the parties. Therefore, I instruct you that if you believe from the evidence that at the time this contract was made Mr. Bailey was informed that the iron which he furnished was intended for use in these elevated railroads of New York, and about that there can be no doubt, because Mr. Bailey says that such was the case, that he was so informed, then I say that the law implies a warrant on the part of these plaintiffs that the iron furnished by them under their contract should be adapted in quality and otherwise to such intended use, and that if at any time afterward it is ascertained and is satisfactorily shown to you that the iron was not of such quality as was fairly adaptable to the use for which it was intended, the warrant was broken, and the defendants are entitled to such damages as they have shown to have sustained by reason of such breach.

Counsel for plaintiffs present the two following points:

1. "In a contract for the purchase of an unmanufactured article, which both parties know is to be used for a special purpose, there is no implied warranty by the seller that the article furnished is to be of a quality fit for the object for which the article is known to be ordered, unless it appear the buyer relied, as regarded the quality, upon the judgment of the seller and not upon his own judgment. Such knowledge does not alter the terms of the contract, nor does it form a part thereof unless made so by express agreement. The maxim of *caveat emptor* then applies.

"I answer that as follows:

"In a bargain and sale of an unmanufactured article, which the seller is informed at the time of the contract is intended for a special purpose, there is an implied warranty that the article to be furnished is fit for the special purpose intended by the buyer. In such case the buyer necessarily trusts to the judgment or skill of the manufacturer.

2. "Whatever may have been the terms of the original contract, if the Edgemoor Iron Works accepted the iron supplied by Mr. Atkins with knowledge of its actual quality, and with knowledge that he did not come up to the specifications of the elevated companies, all loss arising from the subsequent employment of the iron in the railroads must fall upon the Edgemoor Company and not upon Mr. Atkins, for the cause of the loss in such case arose from the conduct of the defendants and not in that of the plaintiffs.

"I answer that as follows:

"This instruction is refused. If there was a warranty of quality,

the defendants do not lose their right to damages for a breach of it by accepting and using the defective article, unless the acceptance is made under such circumstances as show that the quality of the article was satisfactory and was approved. The defendants would be held to have abandoned their right to return the goods, but the failure to return them after discovery of their defective quality will not of itself defeat the defendants' claim for damages for an alleged breach of warranty."

To requote: "The law implies a warrant on the part of these plaintiffs, that the iron furnished by them under their contract should be adapted, in quality and otherwise, to such intended use;" and again, "I do not understand that there is a serious contest here as to the quality of this iron. It was *merchantable iron*."

Here we have it distinctly set forth, that there being no written or express agreement between the parties as to the quality of the material, it must be furnished suitable for its intended use. But who the judge of its fitness? What the criterion of its quality? It may be answered, the testimony of experts must be employed. But where the two experts, who agree exactly as to the necessary qualifications for structural material; one places more importance upon elastic limit than ultimate tensile strength; another looks more to ductility and reduced area of broken section. Yet it may be said, although they differ as to what the most suitable, yet they would all join in pronouncing what was unfit for these purposes. Possibly, in this instance, there would be no difficulty in so doing, but where shall we draw the limit, where make the boundary between good and bad? For instance, a railroad company issues specifications to a bridge-builder, requiring the iron for tension members to stand a tensile strain of 50,000 lbs. per square inch, with an elastic limit of 25,000 lbs. per square inch, and an elongation of 20 per cent. The bridge-builder sends out his specifications and asks the manufacturer for a bid upon an iron suitable for bridge tension members. The iron is furnished, tests are made and results are: Tensile strength, 49,000 lbs.; elastic limit, 27,000 lbs.; elongation, 20 per cent.

The railroad engineer refuses to accept the iron, as not conforming to their specifications. (You may think such a circumstance scarcely possible, but I know it to be a fact.) The bridge builder in turn refuses to accept the material from the manufacturer as not suitable for its intended use; he in turn declares that in his belief a better iron

for its purpose cannot be made, and the contestants carry their case to the courts. The experts are summoned, but the doctors disagree; the twelve wise men, who by the end of the trial are supposed to have imbibed sufficient knowledge to build a bridge or start a rolling-mill, are left to wrestle with the mountain of evidence, which labors greatly —and a mouse comes forth. The case as I have presented it may be an extreme one, yet this same vexed question of quality presents itself to the manufacturer almost daily in some one of its very many phases. The method of treatment for this evil I think is self-evident. The remedy is in the hands of the Government of the United States, and its use is not for the interest of any one class of the people, but is a right which should be demanded by every citizen of this country for his own protection from those horrible calamities whose suddenness so shock all hearers. We have our standard weights and sizes, and by them what incalculable confusion is avoided! Why not have our standard tests as well? True, we have not sufficient data for this, neither shall we ever have if the means for collecting them be left in the hands of single individuals and financial corporations. Their importance is national; their cost necessarily large, too large for private subscriptions. The government alone can bear so great a burden, but a burden made light by the vast importance of the consequent results. I feel a hesitancy in saying anything upon this subject, which has been already well nigh drowned out with the eloquence poured upon it by others. The testing machine now at the Watertown Arsenal is a glorious resting place for the hopes of those who labored so hard and zealously in so good a cause. As a proof of the benefit of government action this very law suit may be cited. Had there been a decreed standard, no dispute would have arisen as to the quality of the iron in question, nor should we have the misfortune of a United States judge pronouncing a decision as to fitness, the standard of which is not absolute, but shifting and irregular. From this case, also, we may draw some useful lessons in regard to contract, lessons which we learn often to our great cost when the proper time has passed away. Specifications as to quality for all materials should be made in writing and rigidly adhered to. Let the engineer state them plainly to the builder and require him to insert them in his specifications to the manufacturer. But above all, let the specifications be reasonable; in framing them primarily combine the experience of the manufacturer with the needs of the user, and a much better result will be obtained than we often

sec. Specifications should not be made of such a nature that the probabilities are about equal whether they can be complied with or not. By so doing the engineer deceives himself and gains no better material for his work. Allow a reasonable margin for the uncertainties which attend all methods of manufacture.

My object is, in this brief paper, to urge upon all present the great necessity of each one doing all in his power to obtain a continuation of those experiments started by the government under such favorable circumstances and so unfortunately brought to a sudden termination when just about to bear such important fruit.

DISCUSSION ON PAPER XV.

ON THE CONNECTING ROD.[1]

By WM. D. MARKS, Member of the Club.

November 15th, 1879.—In No. 3, Vol. 1 of the Proceedings, there appeared a very courteous critique of the article on connecting rods in "The Relative Proportions of the Steam Engine." [2]

I am fully aware of the fact that no defence, however earnest, on my part will force others to accept my views as presented in my recently published work, and therefore I ask but a little space to refer those interested to a continuation of my labors. The book must stand or fall on its own merits.

In the JOURNAL OF THE FRANKLIN INSTITUTE for January, 1879, in a "Note on the Taper of Connecting Rods," I quoted the opinions of C. H. Manning, Past Assistant Engineer U. S. Navy, and of Prof. Thurston, giving in addition a careful discussion of the stresses on connecting rods due to their own weight and inertia.

In that article I did not lay as much emphasis, as I have since had reason to believe I should, upon the accidental stress due to heating of the crank pin and the consequent gripping of the boxes upon the pin.

The stress due to the friction of the boxes upon the pin, although shown to be very small from the recent experiments of Prof. Thurston, should also be considered in a refined discussion, but could hardly be admitted to the brief work of lectures to students.

[1] See Vol. 1, page 158. June, 1879.

[2] The Proportions of the Steam Engine. By Wm. D. Marks. Philadelphia, 1879.

"The initial compression is slightly increased at mid-strol ally about 5 per cent.)", (page 159, Proceedings), is an erroı connecting rods equal in length to four cranks, it would be aboı cent. and very much less for all greater lengths of connecting ı

Mr. Christie cites an engine "*severely taxed,*" 19-inch c 3-inch piston rod, 70 lbs. per square inch pressure, which wou the stress about 28,000 lbs. per square inch on the piston rod, lbs. less than the assumption of 31,000 lbs. ultimate strength, factor of safety of 10. Mr. Kirkaldy's researches and the p experience of all engineers demonstrate the greater liability ı and comparative weakness of large masses of forged iron.

I do not think that any good examples will show a stress per inch on the piston or connecting rods much exceeding 31,000 lb I been warranted by precedent in assuming a greater ultimate *ing* strength than 31,000 lbs. per square inch, I should have c as the point was one to which I gave considerable thought.

Certainly there is no part of an engine subjected to such a ı cation of stresses as the connecting rod, and when in connecti this we recall the uncertainty in value of the constants used, as the uncertainty of the correctness of the laws deduced for lc umns, one must hesitate before overstepping the bounds of wel lished precedents.

NOTES AND COMMUNICATIONS.

No. 5 TURBINE AT FAIRMOUNT.

REGULAR MEETING, MAY 17TH.—Mr. Chas. G. Darrach spoke of the improvements which have been made on what is known as No. 5 Turbine at Fairmount, built in 1871 by Mr. E. Geyelin. The gearing has been entirely disconnected from the walls of the house, allowing 15 revolutions instead of 11 as heretofore.

Mr. Geyelin has now constructed new runners and guide wheels with cycloidal curves, and provided with a partition dividing the buckets vertically into an outside wheel having 1400 square inches of outlet, and an inside wheel having 700 square inches of outlet. These wheels replaced those made in 1871, having a total measurement of discharge of 2400 square inches. This inside area is cut off by an automatic inside gate, at low tide, and a consequent saving of water as the result, as 16 hours out of the 24 the inside division of 700 square inches remains entirely closed.

The wheel was designed to pump eight million gallons, but until these improvements it has pumped but five and a third million gallons per day as an average maximum. No difficulty whatever is experienced in pumping eight and one-half million gallons per day, and Mr. Geyelin expects to be able to make the other wheels pump ten million per day with a smaller amount of water than they are now using to pump six million gallons.

SCHMITT'S REVOLVING SPIRAL SCREEN.

REGULAR MEETING, MAY 17TH.—Mr. J. H. Harden read the following:

This screen has been introduced in the coal districts of Germany with success. Its chief advantages are as follows:

1st. The cost is smaller than that of ordinary screens, and the space occupied in proportion to the work performed is less.

2d. The coal is not so much broken, while the screening into the required sizes is most efficiently done.

3d. Its construction is simple and strong; all parts are readily accessible for repairs.

4th. It requires less power to drive, as the material is more distributed and does not all lie at the bottom of the screen.

The writer is indebted to a notice by Mr. D. P. Morison in the April number of the *Transactions of the North of England Institute of Mining and Mechanical Engineers* for the following information:

The development of the spiral screen shown in the drawing, Figs. 3, 4 and 5, is simply a long plate, perforated throughout with holes of different sizes, according to the sizes into which the coal is required to be separated. This would be about 54 feet long and 4 feet wide, and being wound into a spiral and the ends closed and mounted on a shaft, forms the screen.

Fig. 4 represents a section through the axis of a spiral screen; Fig. 3 a cross section, and Fig. 5 an end elevation. *A* is the shaft on which the screen is mounted; *BB* are carriages carried upon the frames *CC*; *D* is the driving sheave and belt; *E* is the elevator lifting the coals to the schute *F*, which conveys them into the central portion of the screen 1, which is cone shaped to facilitate the delivery of coal which will not pass through the first series of holes. That passing through these holes into the second division of the screen 2 is separated, the pieces too large to pass through the second series of holes being retained upon the plate until that point

comes round where a channel, 2*A* Fig. 3, receives them, down which they are discharged out at the end of the screen. The coals passing into the third division, 3, are separated, and the pieces not passing through the third series of holes are retained until the channel 3*A* comes round, when they are delivered out at the end as before. The "culm" has during this time passed through the holes in division 3, that remaining passing out at the end.

The imperforated or blank part of the plate is to prevent the coal from being returned after passing through the holes, as the delivery through the end channels 2*A* and 3*A* takes place partially at or above the horizontal center line of the screen, and not entirely out of the lowest segment of the circle as in ordinary screens. The perforated plates form segments, and when required can be removed or replaced with others having larger or smaller holes. The screen will be 8 feet in diameter and 4 feet in length. The first perforated plate is a cone. The speed of screen to deliver 400 tons in 10 hours is from 10 to 12 revolutions per minute, but in dealing with very soft coal Mr. Schmitt prefers a slower speed or two screens moving from 6 to 8 revolutions per minute.

The following table shows the comparative results obtained on the Rühr from actual working of ordinary revolving screens and of the spiral screen. In each case the bulk of the coal worked from the mine is composed as follows, viz.:

10	per cent.	larger	than	3	inch	cubes.
11	"	"	"	$1\frac{5}{8}$	"	"
12	"	"	"	1	"	"
13	"	"	"	$\frac{1}{2}$	"	"
10	"	"	"	$\frac{3}{16}$	"	"
22	"	"	"	$\frac{5}{32}$	"	"
22	"	less	"	[illegible]	and culm.	

The coal coming from the mine is passed over an ordinary inclined screen which takes off 20 per cent. of the larger coal, the remainder being delivered by the elevator into the screen by which it is separated into fine sizes.

The arrangement and dimensions of the comparative screens from which the following table is compiled are shown in Figs. 1 and 2.

TABLE OF COMPARATIVE RESULTS.—*Ordinary Screens.*—Fig. 1.—First portion 5 feet 3 inches diameter, 15 feet 9 inches long, 12 revolutions per minute.

Second portion 4 feet 6 inches diameter, 14 feet 9 inches long, 15 revolutions per minute.

No. of Sections of Screen.	Diameter of holes in inches.	Square feet traversed by the Coal per minute.	Coal delivered per minute.	Coal delivered per square foot per minute.
1	$\frac{3}{16}$	2060		
2	$\frac{3}{8}$	1030		
3	$\frac{1}{2}$	880	1490 lbs.	252 lbs.
4	$\frac{3}{4}$	1000		
5	$1\frac{1}{2}$	900		
		5870		

Spiral Screen.—Internal diameter 2 feet 9 inches, external diameter 7 feet, length 4 feet 3 inches, 10 revolutions per minute.

No. of Sections of Screen.	Diameter of holes in inches.	Square feet traversed by the Coal per minute.	Coal delivered per minute.	Coal delivered per square foot per minute.
1	$1\frac{1}{2}$	430		
2	$\frac{3}{4}$	490		
3	$\frac{1}{2}$	540	1490 lbs.	520 lbs.
4	$\frac{3}{8}$	650		
5	[illegible]	760		
		2870		

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The imperforated or blank part of the plate is to prevent the coal from being returned after passing through the holes, as the delivery through the end channels 2.4 and 3.4 takes place partially at or above the horizontal center line of the screen, and not entirely out of the lowest segment of the circle as in ordinary screens. The perforated plates form segments, and when required can be removed or replaced with others having larger or smaller holes. The screen will be 8 feet in diameter and 4 feet in length. The first perforated plate is a cone. The speed of screen to deliver 400 tons in 10 hours is from 10 to 12 revolutions per minute, but in dealing with very soft coal Mr. Schmitt prefers a slower speed or two screens moving from 6 to 8 revolutions per minute.

The following table shows the comparative results obtained on the Rühr from actual working of ordinary revolving screens and of the spiral screen. In each case the bulk of the coal worked from the mine is composed as follows, viz.:

10	per cent.	larger than	3	inch	cubes.
11	"	"	1½	"	"
12	"	"	1	"	"
13	"	"	[illegible]	"	"
10	"	"	[illegible]	"	"
22	"	"	[illegible]	"	"
22	"	less	"	[illegible]	and culm.

The coal coming from the mine is passed over an ordinary inclined screen which takes off 20 per cent. of the larger coal, the remainder being delivered by the elevator into the screen by which it is separated into fine sizes.

The arrangement and dimensions of the comparative screens from which the following table is compiled are shown in Figs. 1 and 2.

TABLE OF COMPARATIVE RESULTS.—*Ordinary Screens.*—Fig. 1.—First portion 5 feet 3 inches diameter, 15 feet 9 inches long, 12 revolutions per minute.

Second portion 4 feet 6 inches diameter, 14 feet 9 inches long, 15 revolutions per minute.

No. of Section of Screen	[illegible]	[illegible]	Coal delivered per minute	Coal delivered per square foot per minute
1	[illegible]	2000		
2	[illegible]	1050		
3	[illegible]	880	1480 lbs.	252 lbs.
4	[illegible]	1000		
5	1½	900		
		5870		

Spiral Screen.—Internal diameter 2 feet 9 inches, external diameter 7 feet, length 4 feet 3 inches, 10 revolutions per minute.

No. of Section of Screen	[illegible]	[illegible]	Coal delivered per minute	Coal delivered per square foot per minute
1	1½	450		
2	[illegible]	400		
3	[illegible]	540	1400 lbs.	520 lbs.
4	[illegible]	650		
5		700		
		2870		

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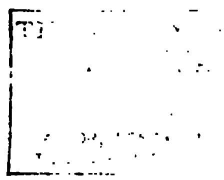

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From these tables it appears that the ordinary screen delivered 1490 lbs. of coal per minute, after passing it over 5870 square feet of screen surface, and that the spiral screen delivered the same quantity after passing the coal over 2870 square feet, or with 50 per cent. less surface traversed, the coals in each case being separated into five sizes.

The circumferential speeds of the screens are, in the case of the first portion of the ordinary screen, 198 feet per minute; in the second, 210 feet per minute, and in the spiral screen, 150 feet per minute, at the mean diameter.

The greater quantity of coal screened on a given surface by the spiral screen is accounted for by the fact of the coals being more distributed, and that they move on a horizontal plane, while in the ordinary screen they have, besides the revolving motion, a lateral one. Then, in the ordinary screen, the "culm" has to find its way through the smallest holes in the first section, the "Pea" through the next, and so on. Thus the largest size coal must traverse the screen from end to end, and so on proportionate to the various sizes of coal; while in the spiral screen this is exactly reversed, the larger size being first separated and only the culm traversing the whole length of the screen.

Another important point gained by the larger sizes being first disposed of is that they were thus prevented from further breakage, and, coupled with the fact that a given quantity of coal has in the spiral screen to pass over only half the surface required in the ordinary screen, fully accounts for the difference in the amount of breakage in the two screens, because this increases in proportion to the surface traversed by the coal in the process of screening. Hence, it is less in the spiral than in the ordinary screen, by 50 per cent. Further, the breakage caused by the large coal being retained on the screen increases as the cube of the size of the pieces (the weight of which is as the cube), and by calculation upon this data it is found that the breakage while in the screen is less in the spiral by 90 per cent. This, so far, is theoretical, but based upon correct principles, and to a great extent confirmed by actual results.

Believing this form of screen to be a valuable improvement, and one that can be used with advantage, particularly in our anthracite coal breakers, the writer has thought it worthy of the attention of those engaged in mining and preparing coal.

BLOCKS FOR SEWER CONNECTIONS.

REGULAR MEETING, MAY 17TH.—Mr. Rudolph Hering exhibited models of sewer connections with house drains, lately used in Philadelphia. They are made of terra cotta, slip glazed, and are 16 inches long, 12 inches deep and 4 inches thick, curving slightly to conform to the radius of the sewer.

In the centre of the block an 8 inch pipe enters, at an angle of 45°, having a socket at its upper end to receive the house drain pipe. By having a rectangular face, with a length of 2 bricks and a depth of 5 courses, they permit of being built into the brickwork, as this progresses, without any cutting of either brick or pipe, and thus form a strong and smooth connection.

The end is closed by a stopper, which can be readily removed when desired. The blocks were built into the sewers opposite each building or building lot. Their cost was from $1 to $1.25 per piece.

THE HARRISON CAR AXLE.

REGULAR MEETING, JUNE 7TH.—Mr. Jos. S. Paxson, introduced by Mr. J. H. Harden, read the following:

The attention of engineers and others has for many years been called to

the necessity of applying some means for lessening or overcoming the friction on curved railroads, which, with the usual arrangement of rigid wheels on axles, is the cause of great loss, both in motive power and in the wear and tear of track and rolling stock. The exact amount of such loss has never yet been satisfactorily demonstrated, the authorities differing widely in their conclusions, but as you are aware, the subject is receiving renewed attention, and experiments are now being made to determine said loss, aided by the improved apparatus which modern engineering talent is able to bring to bear upon this important subject.

The Improved Harrison axle, which I have the honor to exhibit to your society this evening, at the kind suggestion of Prof. Haupt, is designed to, and we think does, accomplish more than any other arrangement of axles with independent wheels that has so far been offered to the consideration of practical men, and for the following reasons (see plate):

1. It does not reduce the strength of the main axle, which is undivided, and is actually strengthened by the collar forged on its centre, while the independent action of the wheels frees it from all torsional strains.

2. No material change is required in the pedestal boxes, brasses or journals, a trifling enlargement of the opening of one box for each axle, to admit the end of the sleeve therein, being all that is needed.

3. Each wheel being fitted rigidly to its axle, revolves independently of its mate.

4. Ample lubrication is provided for by extending the sleeve into the oil box, where the surplus oil from the journal feeds in on the bearing under the hub, while the cavity of the sleeve is supplied through the annular oil chamber and feeds the central bearings. Any surplus therefrom passes under the hub into the oil box and is not wasted.

5. The sleeve is maintained in its required longitudinal position by an annular cap abutting against its inner end and against the central collar, and is secured to said cap by two or four bolts and nuts. A recess is formed in the cap and filled with packing to exclude dust. A washer for the same purpose encircles the end of the sleeve projecting into the pedestal box.

This arrangement, therefore, is most simple in construction, having only *two* additional parts, the sleeve and the cap. It is strong and durable, and not likely to get out of order, and besides it is the least expensive plan yet shown, the extra cost for horse street cars not being more than fifteen dollars each, with an additional weight of about 150 pounds, and for eight wheel steam cars about one hundred dollars extra, with an additional weight of from 500 to 600 pounds each car.

As yet we have experimented only on street railroads.

I herewith submit a copy of a portion of a report made to our company, dated May 1st, 1878, by Charles E. Emery, Civil Engineer, of a series of tests made by him with a dynamometer on car No. 6 of "The Houston, West Street and Pavonia Ferry Railroad," in the city of New York, fitted with the Harrison patent axles, at the 40 foot curve at the intersection of 35th street and Lexington avenue, in comparison with cars Nos. 15 and 16 of said road fitted with common axles.

REMARKS.—"The resistance of the car with the Harrison axle, on a level curve of 40 feet radius, is found to be 34·03 pounds per ton, and of the cars with common axles 53·57 pounds per ton.

"These numbers are in the proportion of 100 to 157·42; so, evidently, 57·42 per cent. more load may be pulled on a curve of 40 feet radius by a given force with the Harrison axles in use than with common axles, corresponding to a saving of resistance with a constant load of 36·48 per cent. The proportion of saving would be somewhat greater on the sharper curves of 30 and 32 feet radius often used on street railroads.

"The actual curve resistance when using the Harrison and common axles respectively, is found to be 22·23 pounds and 41.77 pounds per ton, which are in proportion of 100 to 187·9, so that the saving by the use of the Harrison axle in the extra resistance due to a curve of 40 feet radius is 46·78 per cent.

[redacted]e represents the actual saving in wear and tear on the [redacted] resistance, the percentage previously given

delphia.

Continental Line, car No. 8, to be followed soon by many more.
Ridge Avenue Line, car No. 29.
Market Street Line, car No. 41.

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"The actual curve re[illegible]
axles respectively, is found to be 22·28 pounds and 41.77 pounds per ton, which are in proportion of 100 to 187·9, so that the saving by the use of the Harrison axle in the extra resistance due to a curve of 40 feet radius is 46·78 per cent.

"This percentage represents the actual saving in wear and tear on the flanges and track due to curve resistance, the percentage previously given representing the saving in draft on the curve."

After a run of twelve months, or 22,000 miles, the wheels and axles were taken out from car No. 6 because the treads of two of the wheels were so much chipped or broken out by running over the track and frogs of the New York Central and Hudson River Railroad, which the cars of this line are obliged to do on a part of their route, as to cause the car to leave the rails, which difficulty interferes with all the cars of this line. On examination the axles were found to be so little worn as to warrant new wheels being placed on them.

The flanges and treads, compared with those of rigid wheels under car No. 39, running over the same route, with the same time and mileage, show a wear exceeding 100 per cent. of the rigid more than the Harrison wheels. The subjoined diagrams are made from impressions taken from the Harrison wheels of car No. 6 and the rigid wheels of car No. 39. All the wheels are from the foundry of M. W. White & Co., West 33d street, New York.

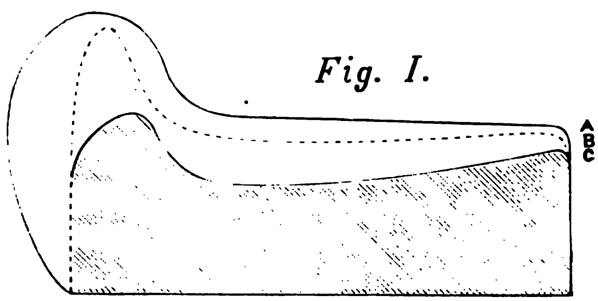

Fig. I.

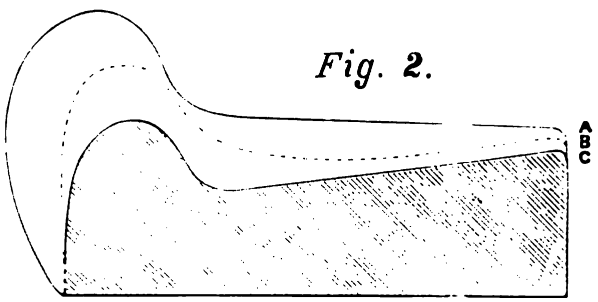

Fig. 2.

Fig. 1 represents the left hand or No. 1 Wharton wheels.

Fig. 2 represents the right hand or No. 3 Wharton wheels, or mates of No. 1.

A.—Original shape of all the wheels.

B.—Present shape of the Harrison wheels, car No. 6.

C.—Present shape of the wheels on the common axles, car No. 39.

I beg leave to add that in addition to car No. 6, above referred to, tests have been and are now being made on the following street roads in Philadelphia.

Continental Line, car No. 8, to be followed soon by many more.

Ridge Avenue Line, car No. 29.

Market Street Line, car No. 41.

Frankford and Southwark (5th and 6th street) Line, steam car No. 10.
" " double deck car No. 4.
" " down town or city car (new) No. 12.
All of which are doing good service daily.

AUTOMATIC FOUL AIR VALVE.

REGULAR MEETING, JUNE 7TH.—Mr. John J. Gorman, introduced by Mr. Hering, exhibited a trap of his own invention, designed to prevent the egress of noxious gases frequently emanating into the street from sewer-inlets. It consists of a balanced valve hung on a shaft running across the back of the basin, with the plate swinging upwards against a joint of lead inclined at an angle of about 30°. When a sufficient amount of water falls upon it the valve opens, permitting the discharge, after which the counter weight closes it again. In striking against a soft metal like lead the edge of the valve is well bedded, and a tight joint is readily secured. A few of these traps are in use in the city and are said to answer well. They are made very substantially and cannot get out of order.

The inventor has applied the same principle to pipes leading from water closets, sinks, etc.

AMERICAN PORTLAND CEMENT.

REGULAR MEETING, OCT. 18TH, 1879.—Mr. Rudolph Hering made some remarks upon the cement manufactured by the Coplay Cement Company, near Allentown, Pa. It is a natural cement and the only American brand that approaches in strength the English Portland.

The rock is an argillaceous limestone forming the upper layers of the Trenton group. To obtain a uniform consistency it is crushed, coarsely ground, and by admixture with water worked into a stiff paste, which is spread out over a large surface and cut up into briquettes. When these are perfectly dry they are piled into the kilns and burned until slightly fused. The mass is then removed and ground fine, when it is ready for the market. The quarry and works are situated on the banks of the Lehigh river and alongside the tracks of the Lehigh Valley Railroad, offering the best facilities for shipment. Regarding its merits as a cement we refer to the excellent paper of Mr. W. W. Maclay, *Transactions of the American Society of Civil Engineers*, December, 1877.

The fact that this cement is not artificial, but depends upon the nature and composition of the various layers of rocks in quarry, necessarily leads to slight variations in quality.

Any briquettes which were not heated up to the point of fusion are culled out, and after being ground are sold as the "Anchor Brand," which in quality is slightly inferior to the best Rosendale cements (samples shown of the cement in the various stages of manufacture.)

EAMES' PETROLEUM PUDDLING PROCESS.

REGULAR MEETING, OCT. 18TH.—Mr. Chas. A. Ashburner read the following:

Within the past week I have procured some facts in regard to the use of crude oil (petroleum) as fuel in the mannfacture of blooms at the Eames Petroleum Iron Works, Titusville, Penn. Although I am not prepared to give a very minute description of the details of the process, or very close estimates as to costs, a general mention of a comparatively new puddling fuel, as employed at those recently constructed works, may interest the members of the Club.

The Eames Oil Fuel Process Company was incorporated in New York

in 1877, and during the past year the Titusville iron works have been constructed at a cost of $25,000.

The Eames process for utilizing petroleum as a fuel has been used for about five years. Blooms, boiler plates, horse shoes, crucible and open hearth steel and glassware have all been manufactured through the agency of this process; with what degree of success I am not prepared to state.

With the exception of the petroleum vapor generator, which of course marks the specific character of the Titusville works, the bloomery is not unlike other bloomeries.

The generator consists of a cast iron vessel with horizontal shelves projecting alternately from opposite sides. The petroleum enters from above through a quarter inch pipe and under 20 pounds pressure. Underneath the generator is a coil of pipe in which the steam from the boiler is superheated by a fire around the coil.

The steam heated to incandescence finds vent in the bottom of the generator and meets the oil as it drips from the lower shelf. The oil is taken up and carried to the combustion chamber, where it is ignited and forced into the furnaces by the air blast which it encounters at this point.

This chamber is built on the bridge wall, and consists simply of a cellular tier of firebricks placed on end extending across the bridge wall. If the combustion chamber has a horizontal thickness of more than 18 inches the bricks fuse. The heat from the two furnaces passes through the flues of two 60 horse boilers, which supply the power for the works. A 12 horse auxiliary boiler furnishes steam for the generator.

The bloomery can be started very quickly, as the combustion of oil takes place just as soon as the steam can be superheated under the generator.

The works have been shut down at 6 P. M.; at 6.15 A. M. the next morning fire is let into the furnace and puddling can be commenced at 7 o'clock.

The furnace is lined with 1000 pounds republic ore No. 1, and charged with 475 pounds pig.

In 45 minutes the iron is puddled, conveyed to the hammers and worked into two blooms six inches square and 20 inches long. The blooms are then placed in the heating furnace, remain for 10 minutes under an intense heat, and are then hammered and made into the finished bloom, weighing from 175 to 200 pounds, and demanding a price ranging from $71 to $80 per ton.

Most of the iron is used for tanks, tubing and casing.

The capacity of both furnaces is 30 tons per day and 20 barrels of crude oil are used.

At present three sets of men are employed, each set consisting of three puddlers, three heaters and six hammerers. The turns are eight hours in length.

No. 6 ENGINE—SPRING GARDEN WATER WORKS.

REGULAR MEETING, OCT. 18TH.—Mr. Darrach remarked that No. 6 engine at the Spring Garden Water Works, built in 1872, by Mr. Henry G. Morris, has lately been partially rebuilt, the slide valve gear replaced by poppet valve gearing, and the inlet chambers to the pump rebuilt and remodeled. The engine is now pumping against 170 feet head instead of 115 feet as formerly, a development of 10 to 15 per cent. greater duty.

PRESERVATION OF TIMBER.

REGULAR MEETING, NOV. 15TH.—Mr. Chas. E. Billin read some notes on the subject. The opinions of many of our principal road-masters, in regard to the life of ties, seem to be very diverse. They, however, place the life of a white oak tie, cut when the sap is down, seasoned and laid in good gravel ballast, at between seven and ten years.

The majority of road-masters apparently live in blissful ignorance of the beneficial effects derived from the use of preservatives; and it is undoubtedly on account of such ignorance that more decided steps have not been taken in this country toward economizing our timber supply, and the cost of maintenance of way of our railroads, by increasing the life of timber used.

Some few experiments have been made within the last ten years toward lengthening the life of ties by Burnettizing, etc.; but the processes were applied in a very crude and imperfect way, and the partial failure of these experiments has done much toward preventing the introduction now of new and thorough processes.

It is estimated that seven million acres of timber are cut each year, in order to furnish ties for railroad use. These figures are not an exaggeration, and it is only astonishing that their magnitude has not, before the past year or two, attracted more attention to the subject and led to the adoption of some preservative process by our larger railroad companies.

Instances were cited of English creosoted ties which had been in use for twenty and twenty-two years, and were in as good state of preservation as when put in track. Creosoted piles, driven at Portsmouth, England, forty-two years ago, were stated to have been found as good above water-line as below, and to have outlived sixteen and seventeen sets of piles cut from the same timber and driven in the same work, but which were not creosoted.

Mr. E. R. Andrews, of New York, in a letter upon this subject, addressed to the Club, says:

"Week before last I went with Mr. Stearns, Asst. Gen. Supt. of the Cent. N. J. Railroad, to examine about a mile of track laid in the spring of 1878 in the outbound main line of that road, beyond Bound Brook, with creosoted Virginia Old-Field Pine ties. They were fairly treated only by the simple pressure process, without the advantages of the steaming process, which I value very highly, because it not only gets rid of the moisture within the wood, but coagulates the albumen of the sap, and also enables me to impregnate the timber more thoroughly. These ties were impregnated only in the sap-wood, and notwithstanding the fact that they were made of a poor quality of wood, yet they were found upon examination to be perfectly sound, and *are not cut in the least by the rail.*

"Engineers constantly say to me that ties cut out before they decay, and I always deny the fact. Even although the larger part of the wood appears to be sound, yet I am confident that when they cut there is a local rotting under the rail and around the spikes sufficient to destroy the tenacity of the fibres so that they lose their hold on the spikes. Otherwise the ties in question would be quite cut away under the severe traffic to which they have been subjected. My own belief is that soft woods will not begin to cut until they begin to decay, and as creosoting will protect them from decay, that when thus prepared they will economically replace oak ties on level tangents, even on trunk lines with heavy traffic. It may be that on curves and steep grades and near stations, where the brakes are usually applied and the wear much increased in consequence, creosoted hard-wood ties would be better. The same would be true with switch ties. Any porous hard-wood will absorb creosote as readily as soft woods and resinous woods are very readily treated, hence the heart of yellow pine creosoted will make excellent switch ties."

BUTLER MINE FIRE CUT-OFF.

Regular Meeting, Nov. 15th.—Mr. John E. Codman said he had recently received some information from Mr. C. T. Conrad, Superintendent, in regard to the success of this work[1]. He read the following descrip-

[1] See vol. 1, p. 83.

tion of the state of affairs at the mine last summer, and a letter from Mr. Conrad:

"The fire in the Butler colliery, a short distance from the Lehigh and Susquehanna Railroad, on the outskirts of Pittston, Penn., continues to burn fiercely. At present it is estimated that ten acres of anthracite are glowing in the upper vein, and the most startling phase of the affair is that the miners in the employ of the company are working the vein beneath. A visit to the workmen in their subterranean oven gives some idea of the intensity with which the fire is raging over their heads. Although separated from them by 70 feet of solid rock, yet the heat is so great that they are compelled to work without a particle of clothing upon them, excepting a light pair of drawers or overalls. The perspiration pours constantly from their bodies, and the temperature is much the same as if they were at work in presence of a roaring furnace. It is very seriously questioned by those understanding the situation whether the men should be permitted to work in this intensly perilous position. Even the air they breathe has to pass through the flames of the burning vein before it reaches them, and it is understood that Mine Inspector Jones has already notified the company that they must construct another shaft, to admit pure air to the workmen, or quit work.

"The fire in the Butler mine has now been burning upward of two years. It originated in the old workings of an abandoned mine, near what was known as the outcrop of the fourteen-foot vein, and on the very highest ground of the property of the Butler Coal Company. The destructive spark was first kindled by a poor, degraded woman, who, having been driven from the shelter of the town, took refuge in one of the numerous caves on the outskirts. Here she made a fire for the purpose of cooking and to keep her warm at night. One midnight she was alarmed by seeing the entire side of the cave on fire, and she fled in terror from the scene. Superintendent Bennet, one of the most practical and careful managers in this region, had his attention called to the fire early in June, 1877. By that time it had made a good deal of headway north-east of the pitch along the pillars, and the course it was taking indicated that it would shortly exhaust itself. There was nothing to give rise then to the apprehension that it would work its way down the pitch or declivity, and immediate steps were taken to cover the 'cave holes' by which the air was admitted to feed the flames. These holes had been caused by the caving of the surface where the mine had been worked out and no pillars left to support the roof. The stopping up of these prevented in a measure the progress of the fire, but owing to the elevated character of the place it was impossible to obtain water in sufficient quantity to be effective. An arrangement was made with a party to open and clear out an old chamber in the mine, intending thereby to cut off the flames, but the work was done in a bungling manner and failed to do what was intended.

"Seeing the threatening character of the element, the company at length adopted a plan, at an enormous expense, which it was hoped would prove effective. A point was selected about eight hundred feet from the fire, at which an open cut was begun from the surface down to the old workings. It was intended that this cut would be 350 yards in length, 20 feet wide at the bottom, and ranging from 12 to 45 feet in depth. The plan was that of Engineer C. T. Conrad, who contemplated at the outset the removal of 60,000 cubic feet of earth, rock and coal in the construction of this magic circle about the fire. He tunnelled a part of the way, and, in the face of obstacles apparently insurmountable, he worked steadily day and night with a strong force of men until his plan was effected. The progress of the flames have since been slow, but now they seem to have gained a great hold, and not only the coal but the superincumbent rock is red with fire. It has now advanced almost to Engineer Conrad's circumscribed limit, and much anxiety is felt lest it should break beyond the boundary.

"The danger lies in the tunnelled part, where it is feared glowing rock will carry destruction over the archway and communicate it to the adjoin-

ing property. The great danger from the fire would arise from its extension into the workings of the Pennsylvania Coal Company, and once there, no power on earth can prevent it from working its way under the town of Pittston."

Mr. Conrad, in a letter under date of Nov. 11th, 1879, says:

"All work was finished on the cut-off September 30th, and changes occurring since then have only served to confirm the announcement, then made to the company, that the work was a complete success. There was no question of the success of any portion of the work except the tunnel. This was not in the original plan, but was afterwards decided upon from economical reasons. After full study and examination on my part, and in opposition to the opinion of many good engineers and experienced coal operators, the tunnel was made to effect a saving of $11,000, and to insure ample time for the rest of the work. Both of these objects the tunnel accomplished, and then the original question came up, could or would the fire cross it?

"There are dry walls on both sides of the tunnel varying from 18 to 32 feet in thickness, with an intervening space of 12 to 18 feet. The walls were carried 4 feet above the coal, *i. e.* 18 feet high in all. The wall on the fire side during the past summer has been heated to a *white heat* through to the exposed face, this occurring at different points from time to time, but all cooling off in a few weeks and never reheating. Finally the great heat penetrated through the 50 feet of rock and earth covering, and so weakened and disintegrated the mass that it finally broke down in sufficient quantities to close up the tunnel with broken rock. This did not occur, however, until after the fire had spent itself and the walls were all cool.

"I conclude that fire will not pass through two stone walls, properly built and proportioned, and with a cold air passage kept open between them. Whilst I adopted not less than 10 feet air space, for safety, I am satisfied that 3 feet would have accomplished the same object."

MINUTES OF MEETINGS.

OF THE CLUB.

MAY 17th, 1879.—An adjourned business meeting was held, Mr Stauffer, V. P., in the chair; 15 members present. The Finance Committee reported $382.29 in the treasury. The Publication Committee reported the third number of the *Proceedings* as in the printer's hands, and would be ready for distribution early in June. Messrs. Darrach and Hering were appointed tellers, and upon a vote being taken they announced Mr. Geo. R. Buckman elected corresponding member, and Mr. W. Frank Newell active member. Upon motion it was decided to adjourn the regular meetings of the Club from June 7th until October 4th. The business meeting was then adjourned.

A regular meeting was held, and Mr. Darrach, Chairman of Committee on Information, made some remarks on Turbine wheels at Fairmount. Mr. Harden read a paper on "Schmitt's Revolving Screen," and exhibited diagrams of the same. Prof. Haupt read a paper (published in *Engineering News*), on the "Early History

of the Education of Engineers." Mr. Young made some remarks upon a comparison of old and new maps. Mr. Hering read the act relating to the Mississippi river improvements as finally amended. He also exhibited models of house drain and sewer connections, and described the same. A formula for the flow of water in open channels, deduced from Kutter's formula, was discussed by Messrs. Hering and Darrach. The Secretary read an extract from a letter from Mr. Billin, describing two ancient bridges over the Rhone.

JUNE 7th, 1879.—A regular meeting was held, Mr. Stauffer in the chair; 10 members and 2 visitors present. Mr. Hering read a communication from Mr. John Bogart, Secretary American Society of Civil Engineers, inviting the Club to attend the Eleventh Annual Convention of the Society, to be held in Cleveland June 17th. Upon motion the invitation was accepted with thanks. Mr. Hering read a letter relating to the Tide-water Pipe Line. Mr. Jos. S. Paxson, introduced by Mr. Harden, read a paper on the Harrison Car Axle, and exhibited a model of the same. Mr. Gorman, introduced by Mr. Hering, exhibited a model of an automatic valve for preventing the egress of foul air from sewers. Mr. Cleemann read a paper upon the flow of water under pressure. Mr. Murphy read an item on the Hydrographic Survey of the Delaware.

SEPTEMBER 6th, 1879.—A special meeting was held, its object being "to nominate candidates for membership for election on October 4th, and for the transaction of any business which might be brought before it."

Seventeen members were present, and Prof. Haupt was called to the chair. After routine business, there was a general discussion on the question asked by Mr. A. R. Roberts, whether iron bridges in expanding and contracting, under changes of temperature, move on their rollers or change their camber.

OCTOBER 4th, 1879.—A business meeting was held, and in the absence of the presiding officers Mr. Madeira was called to the chair; 16 members present. Messrs. Cleemann and Webster were appointed tellers. The vote on admission to membership was canvassed, and the following declared elected: Mr. Ernest Pontzen of Paris, as Corresponding Member; Messrs. Geo. C. Thomas, Chas. S. Heller, John Haug, E. B. Wall, Wm. Forsyth, J. W. Edwards, Frank Lyman as active members.

Mr. Billin announced the preparation of cards of invitation to the rooms for presentation to those persons who, in the judgment of the Club, are worthy of the courtesy.

Messrs. Darrach, Murphy and Cleemann offered a resolution to

amend Article XV of the By-laws by striking out the word "*five*" in the first line and inserting the word "*ten.*"

Messrs. Madeira, C. Sellers, Jr., and Billin offered a resolution to amend the same article by striking out the word "*five*" in the first line and inserting the words "*seven and a half.*"

After considerable debate, Messrs. Ingham, Young and P. Roberts, Jr., offered a resolution to amend the same article by striking out the word "*five*" in the second line and inserting the words "*seven and a half.*"

Messrs. Ingham, Young and Murphy offered a resolution to amend Article III, Sec. 1, of the By-laws so as to insert after the words "*to whom,*" in the second line, the words "in the case of active members."

The Corresponding Secretary announced donations to library. Prof. Haupt, on behalf of the committee to report on the last annual convention of the American Society of Civil Engineers, at Cleveland, made a verbal report, which was accepted and the committee discharged. Mr. Darrach made some remarks on the Simpson engine.

OCTOBER 18th, 1879.—A regular meeting was held, Mr. Stauffer, Vice-President, in the chair; 20 members and 2 visitors present. Mr. Hering described the manufacture of Portland Cement, as practised at Saylor's works, near Allentown, Pa. Mr. Ashburner read some notes concerning the Eames Puddling Process.

The Corresponding Secretary announced several papers recently received from the Institution of Civil Engineers of London, and announced that in their last number of "Abstracts" they had republished Mr. Cleemann's paper, No. XIV, from the *Proceedings* of the Club. He also announced the receipt of valuable plates and publications from the Society of Engineers and Architects of Saxony. Mr. Hering exhibited a full set of plans of work on the contemplated improvement in the sewerage of Boston. Messrs. Darrach, Hering and Cleemann discussed the subject of Water-Way for Culverts.

NOVEMBER 1st, 1879.—A regular meeting was held, Mr. Stauffer, Vice-President, in the chair; 15 members and 2 visitors present. Prof. Haupt read a paper, being a "Report on the Geodetic Survey in Pennsylvania."

NOVEMBER 15th, 1879.—A regular meeting was held, and, in the absence of the presiding officers, Mr. Murphy was called to the chair, 20 members and 3 visitors present. Mr. P. Roberts, Jr., read a paper "On a Recent Legal Decision" in the case between the Edgemoor Iron Company and Atkins Bros.

On motion of Mr. Billin, a committee was appointed to report to the Club as to what action is being taken toward the appointment, by the government, of a Commission on Tests of American Iron and Steel, and to communicate with the American Society of Civil Engineers on this subject.

A note from Prof. Marks in reply to Mr. Christie's article "On the Connecting Rod"[1] was read, and general discussion followed. Mr. Billin read notes on the "Preservation of Timber," and a letter from Mr. Andrews, of New York, upon the same subject. Mr. Ashburner made some further remarks on the Eames Puddling Process. Messrs. Darrach, Hering and Cleemann continued discussion on Water-Way for Culverts. Mr. Codman read some notes on the Butler Mine Fire Cut-off, and a letter from Mr. C. T. Conrad on the subject.

Of the Board of Direction.

May 17th, 1879.—A stated meeting was held and some routine business transacted.

July 11th, 1879.—A special meeting was held, financial business transacted and a special meeting of the Club ordered to be called for Sept. 6th, 1879.

August 22d, 1879.—A special meeting was held to decide upon rooms for the future use of the Club. Mr. Billin was authorized to secure and furnish suitable rooms.

September 20th, 1879.—A stated meeting was held. Nominations for membership were examined and routine business transacted. The Corresponding Secretary was instructed to thank Mr. Chas. A. Young for his valuable assistance in superintending the removal of Club property from the old to the new rooms; also to thank Mrs. Joseph Harrison for her liberal donation to the Library.

Upon motion, the Publication Committee were authorized to copyright all future publications of the Club. The Corresponding Secretary was authorized to obtain cards of invitation, and issue the same only to such persons as the Board may approve.

October 18th, 1879.—A stated meeting was held and routine business transacted. The Corresponding Secretary was instructed to extend to the officers and members of the American Society of Civil Engineers an invitation to attend the meetings of the Club, and to avail themselves of the privileges of the Club rooms.

November 15th, 1879.—A stated meeting was held and routine business transacted. A few purchases were authorized, and sundry bills ordered to be paid.

[1] See p. 158, vol. 1.

CONTRIBUTIONS TO THE LIBRARY.

From the INSTITUTION of CIVIL ENGINEERS. MR. JAMES FORREST, Sec'y, London.
Clark—The St. Gothard Tunnel.
Sang—A Search for the Optimum System of Wheel Teeth.
Higgin—Experiments on the Filtration of Water.
Byrne—Irrigation in Ceylon.
Browne—Technical Reports on the German Railway Union.
McAlpine—The Foundations of the New Capitol at Albany, New York.
Price—Movable Bridges.
Douglass—The Electric Light Applied to Lighthouse Illumination.
Chance—Dioptric Apparatus in Lighthouses for the Electric Light.
Deacon—Street Carriageway Pavements.
Howarth—Wood as a Paving Material Under Heavy Traffic.
Griffith—Improvement of the Bar of Dublin Harbor by Artificial Scour.
Blandy—Dock Gates.
Millar—Strength and Elasticity of Materials.
Gaudard—Bridges Erected in Switzerland.
Sutcliffe—Description of Machinery for the Production and Transmission of Motion in the Large Factories of Lancashire.
Abstracts of Papers in Foreign Transactions and Periodicals. Vol. LVII, parts III and IV.
Buckley—Keeping Irrigation Canals Clear of Silt.
Kinahan—The Traveling of Sea Beaches.
Stoney—A New Balance Bridge over the Royal Canal at Dublin.
St. George—The Street and Footway Pavements of Montreal, Canada.
Shelford—A Graphic Mode of Ascertaining the Flow of a Mill Stream.

From MRS. JOSEPH HARRISON, through MR. THADDEUS NORRIS, Member of the Club:
Journal of the Franklin Institute: 31 vols.—1826–1841, 1860–1862.
The Civil Engineer: 14 vols.—1837–1851.
Burgh—Condensation of Steam.
Burgh—Link Motion and Expansion Gear.
Hutton's Mathematics. 2 vols.
Easton—Street Railways.
Macgregor—The Progress of America. 2 vols.
Malte Brun and Balbi—System of Geography
Percy—Metallurgy of Iron and Steel.
Lesley—Iron Manufacturers' Guide.
Taylor—Statistics of Coal.
The Engineer: 17 vols.—1856–1864.
Encyclopædia Brittanica: 20 vols.
Oddy—European Commerce, 1805.
Report of the Smithsonian Institution, 1870.
Weisbach—Mechanics of Engineering. Vols. 1 and 2.
Rogers—Iron Metallurgy.
Reid—Ventilation in American Dwellings.
Fairbairn—Conway and Menai Tubular Bridges.
Harrison—The Locomotive and Steam Boiler (2 copies).
Malthus—Political Economy.
Binns—Orthographic Projection.
Parsons—Laws of Business
Colburn—Locomotive Engineering and the Mechanism of Railways. 2 vols., Text and Plates.
Clark—Railway Machinery. 2 vols., text and plates.
Tredgold—
Vol. I. Locomotive Engines.
Vols. II and III. Marine Engines.
Vol. IV. Stationary Engines.
Colburn and Holley—Permanent Way of European Railways.
Punch: Vols. I and II.
Isherwood—Experimental Researches in Steam Engineering.
Reports Philadelphia Board of Trade, 1868, [illegible].
Niles' Weekly Register. March 9 to April 27, [illegible].
U. S. Coast Survey. 1855 to 1859, inclusive.
" Patent Office Reports. 1843, 1857, [illegible], [illegible], 1862, 1863, 1864, 1866.
" Land Office Report. 1865.
" Commerce and Navigation. 1858.
Transactions American Institute. 1866.
Lovering—Elements of Electricity and Dynamics. 1842.
Wentworth's Iron and Metal Trades. 1870.
Carpenter—Animal Physiology.
Census of Great Britain. 1811.
Wilson—Russian Army and Campaigns. [illegible]
Explorations for a Railroad Route from the Mississippi River to the Pacific Ocean. Vols. I to II, III, IV, V, VI, VII, VIII, IX, X, XI. I (Supplement).
Siebert's Statistical Annals of the United States. 1818.
United States Census. 1850.
" Naval and Astronomical Expedition. 1855.
Bourne—The Screw Propeller. 1852.
Hodge—The Expansive Steam Engine. 1849.
Practical Mechanic's Journal. April, 1848, to March, 1851.
Transactions Inst. of Civil Engineers. Vol. II, 1838 (London).
United States Report on Revenues. 1866.
Fairbairn—Cast and Wrought Iron. 1854.
Downing—Cottage Residences.
Churton—The Railroad Book of England. 1857.
Report relative to Extortionate Railroad Charges. Pennsylvania Senate, 1868.
Fourth Annual Report Pennsylvania Railroad. 1850.
Report in Equity. Winans vs. Eastern Railroad Company. 2 vols.
Illustrated Catalogue Baldwin Locomotive Works.
Campin—Practice of Hand Turning.
Williams—Combustion of Coal and Prevention of Smoke.
Nicholson and Rowbotham—Algebra.
Robinson—California and its Gold Regions. 1849.
Penley—System of Water Color Painting.
Experiments on Turbines.
Markham—Boiler Explosions.
Johnson—Steam Generators
Burgh—Practical Treatise on Boilers.
McCulloch—Dictionary and Commercial Navigation.
Arrowsmith's Map of America. 1822.
Davies' Map of London.
Map of Portugal. 1790.
" Spain. 1790.
Brunel—Description and Plan of "Great Eastern"
Mitchell's Map of Texas, Oregon and California. 1846.
King's Railway Manual. 1868.
Rowbotham—Landscape Painting.
Smith's Map of Europe. 1843.

Austin's Map of Liverpool. 1849.
Thomson's Practical Perspective.
Edwards—The River Amazon.
Armstrong—Steam Boilers.
Armstrong and Bourne—Boiler Engineering.
Gilbert—Railways of England and Wales.
Renwick—Compendium of Mechanics. 1830.
Barnes' Map of Philadelphia. 1854.
Pitkin—Statistics of the United States. 1817.
Nystrom—Parabolic Construction of Ships.
Report of Survey in Mexico. Mexican and Pacific Coal, Iron and Land Company.
Carey's Map of London. 1843.
Rembrandt Peale—Book of Drawing. 1842.
Organ für die Fortschritte des Eisenbahnwesens. 1853.
English Patents on Steam Engineering.

From the AMERICAN INSTITUTE of MINING ENGINEERS.
Dr. Thos. M. Drown, Sec'y.

Dudley—The Chemical Composition and Physical Properties of Steel Rails.
Church—Accidents in the Comstock Mines and their Relations to Deep Mining.
Kent—Curious Phenomena in Test of Bessemer Steel.
" Apparatus for Testing the Resistance of Metals to Repeated Shocks.
" Autographic Transmitting Dynamometer.
Bailey—The Tessié Gas Producer.
" Washing Phosphoric Pig-iron.
Macfarlane—Use of Determining Slag Densities in Smelting.
Proceedings of the Pittsburgh Meeting.
Coxe—Note on the Wear of an Iron Rail.
Wait—Antimony Deposits of Arkansas.
Witherbee—Working of Three Hearths at Cedar Point Furnace.
Shinn—Pittsburgh, its Resources and Surroundings.
Kempton—Sketches of the New Mining Districts at Sullivan, Maine.
Hartman—Regenerative Stoves, a Sketch of their History and Notes on their Use.
Kimball—Relations of Sulphur in Coal and Coke.
Church—Recent Improvements in Concentration and Amalgamation.
Birkinbine—Experiments with Charcoal, Coke and Anthracite in Furnace.
Raymond—Note on Zinc Deposits of Southern Missouri.
" The Hygiene of Mines.
Proceedings of the Montreal Meeting.

From the CIVIL ENGINEERS' CLUB of the North-west:

Sooysmith—The Glasgow Bridge Substructure.
Farquhar—Blasting Under Water in Rivers with Rapid Currents.
Ansley—City Drainage.
Liljencrantz—Pier Construction of Recent Date.
Cole—Anchor Ice as Affecting Public Water Supply.

From MR. E. B. WESTON, Providence:

Reports (32) of the Boards of Water Commissioners of the City of Providence. Jan., 1870, to March, 1879.
Report on the Water Supply of Providence. Oct., 1878.
Pawtucket Water Works—Seventh Quarterly Report. Dec., 1878.

From MR. CHAS. H. SWAN, Providence:

Annual Report of the City Engineer of Providence. 1879.
Reports (9) on Sewers of Providence. Feb., 1874, to Nov., 1876.
Shedd—Report on the Sewerage of Providence. 1874.

From CHAS. E. BILLIN, member of the Club:

Stockpole—The Problem of River Mouths.
Julien—Fissure Inclusions in the Fibrolitic Gneiss of New Rochelle, N. Y.
Report of Engineers U. S. Navy upon Experiments with Saturated and Superheated Steam.
G. B. Dixwell—Cylinder Condensation.

From the DEPARTMENT OF THE INTERIOR, Washington, D. C.:

Annual Report of Dr. F. V. Hayden. 1876.
Powell—Arid Lands of America.
Bulletins. Vol. IV, No. 4. Vol. V, Nos. 1 and 2.

From the AMERICAN SOCIETY of CIVIL ENGINEERS, New York.
Mr. John Bogart, Sec'y.

Transactions. June, July, August, September and November.

From the SOCIETY of ENGINEERS, London,
Mr. P. F. Nursey, Sec'y:

1 vol. Transactions. 1878.

From the SOCIETE des INGENIEURS CIVIL, Paris:

4 vols. Mémoires de la Société. January to August, 1879.

From MR. CHAS. LATIMER, C.E.:

Proceedings of the Roadmasters' Meeting of the A. & G. W. R. R. Nov., 1878.
Chart Showing the Financial and Operating Statistics of the A. & G. W. R. R. for fourteen years.

From L'ADMINISTRATION des PONTS et CHAUSSEES, Paris:

1 vol. Personnel 1879. 11 vols. Annales des Ponts et Chaussées. January to November, 1879.

From the ESSAYONS CLUB, New York: 1 vol.
Heger—Useful Tables for Finding Specific Gravity.
Palfrey—Notes on the Use of Logarithms.
Abbot—Testing of Medium and High Tension Fuses.

From the RUSSIAN IMPERIAL TECHNIC SOCIETY:

Proceedings. 4 vols.

From the PORTUGUESE SOCIETY of CIVIL ENGINEERS:

Proceedings.

From the SWEDISH SOCIETY of CIVIL ENGINEERS:

Proceedings. Parts 2, 3, 4 and 5, 1879.

From GENERAL HERMAN HAUPT, member of the Club:

Report on Processes of Gill and Bentley for producing Cheap Hydrogen for Light and Fuel.

From the AMERICAN PHILOSOPHICAL SOCIETY:

Proceedings. January to June, 1879. 1 vol.

From the PHILADELPHIA SOCIAL SCIENCE ASSOCIATION:

Kellogg—Thoughts on the Labor Question.

From JAMES F. SMITH, C.E., Reading, Pa.:

The Future Water Supply of the City of Philadelphia.

From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Ayres:

4 pamphlets. Proceedings.

From MR. FRANKLIN W. SMITH, Boston:

Reports (1, 2, 3 and 4) to Board of Aid to Land Ownership.

From HON. JUDGE CHAMBERLIN, Superintendent Boston Public Library:

Catalogue of Library ("Bates' Hall Supplement").

From WM. H. McFADDEN, Esq., Chief Engineer of Philadelphia Water Department, member of the Club:

Report for 1878.

From the SAXONIAN SOCIETY of CIVIL ENGINEERS:

Proceedings and Charts.

From PROF. L. M. HAUPT:

Pleadings and Proofs, United States Circuit Court Eastern District of Pennsylvania. Hoffman vs. Young.

From MR. JOHN COLLETT:

From the AERONAUTICAL SOCIETY of GREAT
Report Geological Survey of Indiana. 1878.
BRITAIN:

Proceedings. 1878.

LIST OF MEMBERS.

Additions.

Haug, John. 417 Walnut street. Elected Oct. 4th, 1879.

Heller, Chas. S. 33 N. 7th street. " " "

Thomas, Geo. C. P. R. R., Harrisburg, Pa. " " "

Wall, E. B. P. R. R., Altoona, Pa. " " "

Chance, H. M. 907 Walnut street. Elected Dec. 6th, 1879.

De Kinder, Jos. J. 307 Walnut street. " " "

Freeland, F. T. University of Pa. " " "

Pontzen, Ernest. 4 rue Castellane, Paris, France. Elected Corresponding Member Dec. 6th, 1879.

Changes and Corrections.

Cranmer, W. C. 1930 Christian street.

Harden, J. H. Phœnix Iron Co. Phœnixville, Chester county, Pa.

McClellan, O. E. Supt. P. R. R. Div. 32d and Market streets.

Sanders, R. H. 410 S. 15th street.

Sellers, Wm. F. Edge Moor Iron Co. Edgmoor, Del.

Soule, R. H. Supt. M. P.—N. C. Railway. Baltimore, Md.

Stauffer, D. McN. Contractor's Office, Dorchester Bay Tunnel. Boston, Mass.

ANNOUNCEMENTS.

Members are requested to send to the Corresponding Secretary, at the Club rooms, any information, either original or published, which they may have in regard to the subjects of Narrow Gauge Railroads and City Street Railways. Mr. Ernest Pontzen, Corresponding Member, is preparing a work on American Railway Practice, and is especially desirous to obtain information on the above-named subjects.

Members are requested to insert, in parenthesis, the metric equivalents of all weights and measures used in papers read before the Club; also, to place a metric scale in juxtaposition with ordinary scale upon all drawings illustrating papers.

PROCEEDINGS
OF THE
ENGINEERS' CLUB OF PHILADELPHIA.
ORGANIZED DECEMBER 17th, 1877.

XXI.

ANGULAR PITCH OF SQUARE-THREADED SCREWS.

By WILFRED LEWIS, Member of the Club.

Read December 20th, 1879.

The efficiency of any mechanism is measured by the ratio of the work utilized to the work expended. This is always an important factor in determining the excellence of machinery, and it deserves special consideration in the case of feed and lifting screws, which often form essential elements of a design.

The screw may be used, in practice, either as a means of performing work, or for the purpose of binding and holding together various parts of machines or structures. In the latter case the thread is generally V-shaped, and its pitch and depth are determined by a recognized standard. Here the stability of constructions demands a small angular pitch, to prevent the possibility of jarring loose.

In the former case the square thread is the common and approved form, but no special standard of pitch is strictly adhered to, and inclinations ranging from 5° to 30° are often used.

The efficiency of a screw is increased by the reduction of its frictional work, which will be found to depend upon the coefficient of friction, the angular pitch of the thread, the shape of the thread, and the diameter of the supporting step or collar. It is, therefore, desirable in cases where the screw is used to perform work, that its frictional resistance should be reduced to a minimum, and it is the object of this paper to investigate the relation between angular pitch and frictional work, and to derive a general formula by which the angle corresponding to the least amount of frictional work can be determined.

The first step necessary toward the reduction of friction is that the thread shall be square. This seems to be well understood, and calls

for no special demonstration. It will suffice to say that the friction is proportional to the cosec. of the angle which the generating line of the thread makes with the axis of the screw.

The most common pitch for square threads is double that of V threads for the same diameter, but in the case of feed and lifting screws this is sometimes doubled, or even trebled, and it is found to be true that the work done in overcoming a given resistance or in lifting a given weight is thereby lessened.

The reason of this is apparent, for in screws of very fine pitch it will be seen that an undue amount of work is performed by the excessive sliding. On the other hand, it is also evident that if too coarse a pitch be used the power of the screw will be again lost in friction.

It therefore becomes necessary to determine that point at which the least amount of work will be absorbed by friction.

The angle at which this takes place must be a function of the frictional resistances, for were friction left out of consideration the work done in raising a given weight a given distance would be constant and independent of the pitch used.

The force necessary to slide a weight up or down an inclined plane is clearly demonstrated in Weisbach's Mechanics, and a similar construction will serve to determine the force required to overcome the resistance of a screw.

Let the right angled triangle ABC be the development of a spiral, the angle a being equal to the angular pitch, which is the angle of the spiral to a plane normal to the axis of the screw. Given the weight of the block O, represented by OW, to find the magnitude of the force parallel to AC, which will cause the block to slide up the incline AB. S_0 is the component of W along AB, and N_0 the normal component.

S_1 is the component of P along AB, and N_1 the normal.

$N_0 + N_1 = W \cos. a + P \sin. a, S_1 - S_0 = P \cos. a - W \sin. a$

Let φ = coefficient of friction, then

$$P \cos. a - W \sin. a = \varphi \, W \cos. a + \varphi \, P \sin. a$$

or $$P \cos. a = W \sin. a + \varphi \, (W \cos. a + P \sin. a)$$

multiplying by cosec. a

$$P \cot. a = W + \varphi \, W \cot. a + \varphi \, P$$

whence $$P \, (\cot. a - \varphi) = W + \varphi \, W \cot. a \text{ and}$$

$$P = \frac{W + \varphi \, W \cot. a}{\cot. a - \varphi} \qquad (1)$$

This force P multiplied by the mean radius of the screw will give the twisting moment required to raise a given weight without step or collar.

Similarly it may be shown that the force required to lower a given weight may be expressed by the equation

$$P_1 = \frac{\varphi\ W \cot.\ a - W}{\cot.\ a + \varphi} \tag{2}$$

The moment required to overcome the resistance of a step or collar is equal to $\varphi\ W$ into the mean distance of the rubbing surface from the centre of the screw.

Let $R =$ outside radius of collar.

Let $r =$ inside " "

Then it can readily be shown that the mean radius

$$r_0 = \tfrac{2}{3}\frac{R^3 - r^3}{R^2 - r^2} \tag{3}$$

The same formula may be used to determine the mean radius of the screw, but, inasmuch as r is seldom less than $\cdot 8\ R$, it will in most cases be sufficiently accurate to assume for the pitch diameter of the screw the diameter at the middle of the thread.

If $d =$ pitch diameter of screw, and

$D =$ " " " step or collar,

then $\dfrac{D}{d} = n$ will express the ratio of the effective lever arms of collar and thread.

The total force acting at the pitch line of the screw required to overcome all resistances will then be expressed by

$$P = \frac{W + \varphi\ W \cot.\ a}{\cot.\ a - \varphi} + n\,\varphi\ W. \tag{4}$$

The work done in raising a weight through the distance BC, considered as unity, will be expressed by the equation, $P \cot.\ a =$ work done $=$

$$W.\ \frac{\cot.\ a + \varphi \cot.^2 a}{\cot.\ a - \varphi} + n\,\varphi\ W \cot.\ a. \tag{5}$$

By differentiating and equating to zero, the following expression is obtained for the angle corresponding to the least amount of frictional work,

$$\cot.\ a = \varphi + \sqrt{\frac{1 + \varphi^2}{1 + n}}. \tag{6}$$

Thus when the coefficient of friction and the value of n are known, the angular pitch corresponding to the greatest efficiency is readily obtained.

For example, let the coefficient of friction be ·15, and let the screw be supported upon a step equal in diameter to the root of the thread, in which case n will equal about ·5.

Then, applying the formula

$$\cot. a = \cdot 15 + \sqrt{\frac{1 + \cdot 0225}{1 + \cdot 5}} = \cdot 9525$$

$$a = 46^\circ\ 23'$$

The most efficient pitch will in general be steeper than can be conveniently made in practice, and it is besides open to the objections of necessitating a large increase in diameter, and of diminishing the power.

In order to choose an advantageous pitch, with least sacrifice of power or material, plates 1 and 2 have been constructed.

In plate 1 abscissæ denote the angular pitch of the thread, and in plate 2 they denote the long or axial pitch in terms of the pitch diameter of the screw.

Plate 2 has been constructed by substituting the corresponding ordinates in plate 1, and is given as a form more convenient for practical use.

In these plates the coefficient of friction has been assumed at ·15, as determined from experiments to be described.

Ordinates from the horizontal line aa, measured to the curves de and df, are proportional to the force required at pitch of screw to raise or lower a given weight when $n = 0$.

Ordinates are to be measured from n, n', n'', when $n = \cdot 5$, $1 \cdot 5$ and 3, respectively. From which it follows that the points of intersection of df with a, n, n' and n'' give the greatest angle at which the screw will stand without running down in those particular cases.

Ordinates measured from aa to gh and gk represent, respectively, the diameters of screws for equal torsional strength and for equal angular deflection.

Ordinates from BB to the curves A, N, N' and N'' represent the total work done when $n = 0$, ·5, 1·5 and 3.

$BC =$ useful work done, and ordinates above $CC =$ frictional work.

From plate 1 it becomes evident that by the reduction of n' to n, or

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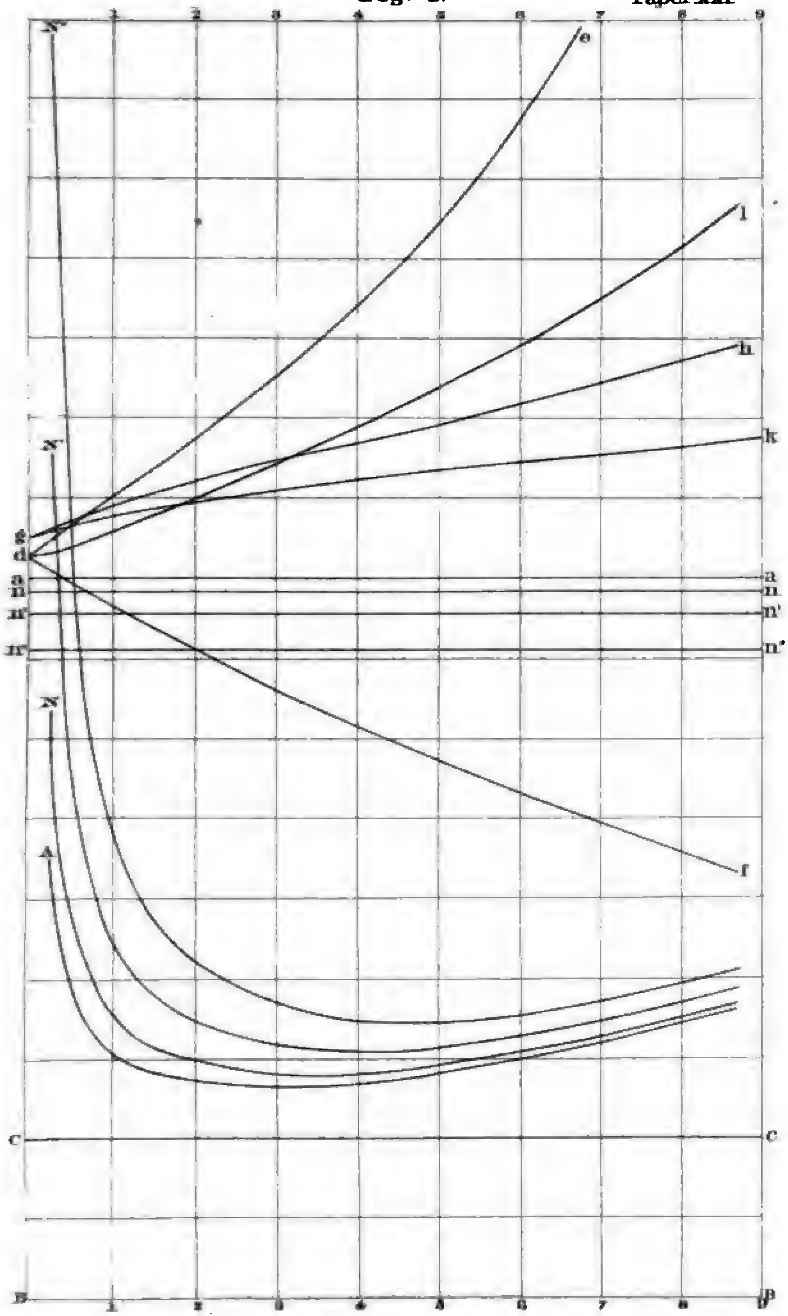
Fig. 4.



a change from an ordinary collar to step bearing, that a screw whose pitch was 5° might be increased to 13° without sacrifice of power, and with a saving of ·6 of the work consumed by friction.

To find the force required to turn a V-threaded screw, let β = angle which generating line of thread makes with the axis, then from equation (4)

$$P = \text{cosec.}\ \beta \frac{W + \varphi\ W \cot.\ \alpha}{\cot.\ \alpha - \varphi} + n\,\varphi\ W. \qquad (7)$$

In the U. S. standard V thread, $\beta = 60°$ and $\alpha = 2\frac{1}{2}°$ about, and the value of n for a nut or bolt head = 1·5 nearly.

Then, by substitution in the above formula,

$$P = \left(1{\cdot}15\,\frac{1 + {\cdot}15 \times 22{\cdot}9}{22{\cdot}9 - {\cdot}15} + 1{\cdot}5 \times {\cdot}15\right) W = {\cdot}45\ W$$

When friction is disregarded P should equal tan. $\alpha\ W = {\cdot}0437\ W$. Hence it is evident that the stress upon a standard V threaded bolt will be only $\frac{{\cdot}0437}{{\cdot}45}$, or ·1 of the stress calculated in disregard of friction, and this has been actually confirmed by experiment.

Similarly it may be shown that the stress upon a common square threaded bolt whose angular pitch = 5° is ·19 of that calculated in disregard of friction.

The stress exerted by a given force P will be practically the same in either case, although the square thread is double the pitch of the V, and this is a striking proof of the disadvantage of using very fine pitches.

The coefficient of friction ·15 was determined by experiments upon the feed screw of a 36-inch vertical drill at the machine works of Wm. Sellers & Co. The essential features of the apparatus are shown in Fig. 2.

The feed screw to which the spindle is attached is suspended in a cast iron nut, and is prevented from revolving with the nut by links at A.

A cord was wound around the circumference of this nut, to which, after passing over a pulley, weights were suspended at F. Weights ranging from 50 to 2000 lbs. were suspended at W, and the force at F necessary to start the nut as well as to keep it in motion was carefully determined in each case.

It was in general found that the force required to start the nut was about 1·3 times that required to keep it in motion, and that the force

required to keep it in motion varied slightly with the speed, growing less as the speed increased.

But inasmuch as there was no available means of determining the rate of motion, the speed was kept as slow as possible. Due allowance was made for the friction of the pulley and the coefficient φ calculated by substitution in equation (4).

It is sometimes necessary, apart from the questions of torsional strength and angular deflection, to know the combined effects of torsion and tension upon a movable nut worked by the screw, in order to insure steadiness of motion. In other words, to find the ratio of the diameters of screws of various pitches in which the total resilience shall be constant.

Thus, let it be required to find the diameter of any screw whose total resilience shall be equal to that of a screw whose diameter is unity and angular pitch indefinitely small.

The elastic extension of wrought iron under a proof load of 30,000 pounds, is, according to D. K. Clark, about ·0011 times its length, and it can be deduced, from the formulæ for deflection given by the same author, that a load of 30,000 pounds applied at the circumference of a shaft of 1 inch section will produce a circular deflection of ·0154 times the length of the shaft. It therefore follows that when $P = W$ the ratio of circular deflection to linear extension will be $\frac{\cdot 0154}{\cdot 0011} = 14$, and if the linear extension be assumed at unity the circular deflection will be 14 times $\frac{P}{W}$, as calculated by equation (1), or by 14 P when W is assumed at unity, and for the sake of simplicity this assumption will be made in all subsequent formulæ.

The resilience of extension is felt directly by the movable nut, but that of circular deflection must be multiplied by the tangent of the angular pitch, to determine its effect upon the steadiness of motion. Both vary inversely as the square of the diameter of the screw when the resistance is constant, and hence the conditions necessary to insure equal steadiness of motion in screws of various pitches, having the same resistance to overcome, are expressed by the equation

$$\frac{1 + 14\, P \tan. a}{d^2} = \text{a constant.}$$

The ratio of the diameters can, therefore, be determined by the equation

$$d = \sqrt{1 + 14\, P \tan.\, a} \qquad (8)$$

By substituting the values of tan. a the following values of d are obtained:

When $a = 0°$	$d = 1$	When $a = 5°$	$d = 1·13$
" $a = 10°$	$d = 1·35$	" $a = 20°$	$d = 1·94$
" $a = 30°$	$d = 2·74$	" $a = 40°$	$d = 3·64$
" $a = 50°$	$d = 5·14$	" $a = 60°$	$d = 7·75$

For steel the ratio of circular deflection to linear extension may be taken at 7, and a curve similar to that for wrought iron calculated by the formula

$$d = \sqrt{1 + 7\, P \tan.\, a} \qquad (9)$$

The curve of diameters for uniform total resilience in wrought iron is represented by $d\,l$, and thus the power, strength, stiffness, resilience and frictional work for any pitch can at once be seen.

Another curve, showing the comparative steadiness of motion in screws of the same diameter but of different pitches, might be computed by the formula $1 + 14\, P \tan.\, a =$ comparative resilience of screws of constant diameter.

The application of the preceding principles to differential screws shows an enormous loss in frictional work without the commonly supposed gain in power.[1] If, in Fig. 2, the cast iron nut which revolves upon its bearing should be made to move longitudinally, by having a thread, whose pitch should be in the same direction as the internal thread, cut upon its outer surface, then the advance of the spindle would be measured by the difference in axial pitch of the two screws.

The throw of the spindle, however, would be necessarily much restricted by such an arrangement, and the substitute is sometimes resorted to, of making the screw and nut both revolve in the same direction by suitable gearing.

In either case the object of the device is to multiply the power without reducing the size of the thread to that of a corresponding simple screw and nut.

How much the power may be multiplied can be determined from a general solution for each case.

In the first case, let

[1] The word power is used advisedly in the sense of force, and nothing more than the relation $\frac{W}{P}$ should be understood by it in any part of this paper.

$a =$ diam. of external screw; $e =$ axial pitch of external screw;
$b =$ " internal " $f =$ " " internal "
$\frac{b}{a} = d =$ ratio of diameters; $\frac{f}{e} = p =$ ratio of pitches;

$\alpha =$ angular pitch of external screw;
$\beta =$ " " internal "

Then $\cot. \alpha = \frac{\pi a}{e}$, and $\cot. \beta = \frac{\pi b}{f} = \cot. \alpha \frac{eb}{af} = \frac{\pi d a}{pe}$

The force required at pitch line of external screw to move it against a resisting weight can be determined from equations (1) and (2), and may be expressed by

$$F = P + P^1 = \frac{1 + \frac{\varphi \pi a}{e}}{\frac{\pi a}{e} - \varphi} + d \frac{\frac{\varphi \pi d a}{pe} - 1}{\frac{\pi d a}{pe} + \varphi} \tag{10}$$

and the force required to turn it in the opposite direction will be given by the equation

$$F_1 = P_1 + P = \frac{\frac{\varphi \pi a}{e} - 1}{\frac{\pi a}{e} + \varphi} + d \frac{\frac{\varphi \pi d a}{pe} + 1}{\frac{\pi d a}{pe} - \varphi} \tag{11}$$

The direction in which the external screw should be turned in order to perform work against resistance, depends upon the relative magnitudes of e and f.

When $e > f$, equation (10) expresses the force required to raise a weight, and equation (11) the force required to lower it, and *vice versa*.

For example, let $a = 2 \cdot b = 1 \cdot e = \cdot 5$, and $f = \cdot 4$, then $d = \cdot 5$ and $p = \cdot 8$, and applying formula (10):

$P = \cdot 2825$, $P_1 = \cdot 0111$, and consequently $F = \cdot 2436$

Also from formula (11):

$P_1 = \cdot 07$, $P = \cdot 1115$, and $F_1 = \cdot 1815$

Here there is actually less power gained than could have been derived from the outside screw alone when used without step or collar.

The total work done is given by the formula

$$U = \frac{F \pi a}{e - f} = \frac{\cdot 24 \times 3 \cdot 14 \times 2}{\cdot 1} = 15 \cdot 7$$

times the useful work.

When the screw and nut both revolve with different angular velocities there are three pairs of rubbing surfaces, the step upon the screw, the collar upon the nut, and the screw threads themselves.

Let n = ratio of effective diameters of step and screw;
" n^1 = " " " nut "
" a = angular pitch of screw;
" v = " vel. "
" v^1 = " " nut.

Then, when $v > v^1$ the force required to turn the screw at its pitch line against a resistance can be expressed by the equation

$$F = \frac{1 + \varphi \cot. a}{\cot. a - \varphi} + n\,\varphi + \frac{v^1}{v}\left(n^1\,\varphi - \frac{1 + \varphi \cot. a}{\cot. a - \varphi}\right) \qquad (12)$$

and when $v^1 > v$, the equation becomes

$$F = \frac{1 + \varphi \cot. a}{\cot. a - \varphi} + n^1\,\varphi + \frac{v}{v^1}\left(n\,\varphi - \frac{1 + \varphi \cot. a}{\cot. a - \varphi}\right) \qquad (13)$$

The force required to lower a weight when $v > v^1$ is

$$F_1 = \frac{\varphi \cot. a - 1}{\cot. a + \varphi} + n\,\varphi + \frac{v^1}{v}\left(n^1\,\varphi - \frac{\varphi \cot. a - 1}{\cot. a + \varphi}\right) \qquad (14)$$

and when $v^1 > v$ the equation becomes

$$F_1 = \frac{\varphi \cot. a - 1}{\cot. a + \varphi} + n^1\,\varphi + \frac{v}{v^1}\left(n\,\varphi - \frac{\varphi \cot. a - 1}{\cot. a + \varphi}\right) \qquad (15)$$

To take an example, let $n = \cdot 5$, $n_1 = 1\cdot 5$, $a = 5°$, $v = 3$, and $v^1 = 2$, then from equation (12) $F = \cdot 305$ The ratio of the total work consumed to the useful work done can be obtained from this by the formula

$$U = F \cot. a \,\frac{v}{v - v^1} \qquad (16)$$

when $v > v^1$, or by

$$U = F \cot. a \,\frac{v}{v^1 - v} \qquad (17)$$

when $v^1 > v$, and for the present case $U = 10\cdot 46$. The same screw working in a fixed nut would give $P = \cdot 315$ and $U = 3\cdot 6$, and thus from the above formula the power and efficiency for either form of differential screw can be determined, and the inefficiency and absurdity of any particular case thereby demonstrated.

XXII.

ON WATER GAS FROM COAL AND PETROLEUM,

ITS CALORIFIC ENERGY AND INTENSITY AS COMPARED WITH SIEMEN'S GAS, AND COAL.

By HERMAN HAUPT, C.E., Honorary Member of the Club.

Read January 3d, 1880.

Is it possible to increase the calorific power of coal by converting it into water gas? This possibility is very generally denied, and the reason assigned is that no greater calorific power can be developed in the reunion of elements than was exerted in effecting their dissociation.

Conceding the truth of this position, the answer is simply that it does not in any manner express the conditions of the question.

Suppose that two elements, the union of which is accompanied by a certain degree of calorific energy, shall have been dissociated by an application of force, the energy of reunion of the same elements may not, and probably will not, exceed the force exerted in the separation.

But suppose there is no reunion of the same elements, but that each of the separated elements forms a new union with two foreign elements, or with two new and different equivalents of a single element. Will there not be two operations, each developing an amount of energy equivalent to that which would attend the reunion of the two elements originally dissociated, and thus double the calorific development?

This is precisely the condition of things which exists in the case of water gas. Carbon, at a proper temperature, decomposes steam, with formation of equal volumes of carbonic oxide and hydrogen, each of these volumes requiring precisely the same amount of oxygen and developing the same number of heat units in combustion.

Now, it is conceded that if the dissociated hydrogen and oxygen are reunited, a degree of calorific energy will be developed not greater than was exerted in effecting their separation; but it must be remembered that there is another and equal volume of combustible gas, carbonic oxide, which requires another equal volume of oxygen supplied by air, which costs nothing, and in the union develops the same num-

ber of heat units as in the combustion of the hydrogen. Must not the theoretical calorific power, therefore, be doubled?

It will be interesting to pursue this investigation further, and compare the number of calorific units required to effect the dissociation of water by means of carbon with the number of units developed by reunion or combustion of the liberated hydrogen.

The *calorific energy communicated to* 1 *lb. of carbon and* $1\frac{1}{2}$ *lbs. of water* must be sufficient

1st. To overcome the latent heat of carbon.

2d. To raise the temperature of the carbon to 2250°.

3d. To raise 1·5 lbs. of water vapor to 2250°.

The latent heat of carbon. One pound of carbon uniting with two equivalents, $2\frac{2}{3}$ pounds, of oxygen, and burned to carbonic acid develops 14,500 units. One pound of carbon in carbonic oxide, uniting with one equivalent, $1\frac{1}{3}$ lbs. oxygen, develops 10,204 units. The difference is 4296 units, which represents the calorific energy of the union of 1 pound solid carbon with one equivalent of oxygen.

It appears, therefore, that one pound of carbon, in the form of *gas*, uniting with one equivalent of oxygen develops 10,204 units, but one pound of *solid* carbon uniting with an equal quantity of oxygen developes only 4296 units.

The difference, 5908 units, is expended in effecting the change of condition and becomes latent, the latent heat of carbon being six times that of steam.

To raise one pound of carbon to 2250°, the specific heat of carbon being ·2411, will require $\cdot 2411 \times 2250° = 540$ units. One pound of carbon requires $1\frac{1}{3}$ lbs. oxygen, and $1\frac{1}{3}$ lbs. oxygen unite with ·166 lb. hydrogen, and the heat units developed in the combustion of one pound hydrogen, less the latent heat of steam, will be 53,800, available for calorific power.

$1\frac{1}{3}$ lbs. oxygen + ·166 lb. hydrogen = 1·5 lbs. water.

To convert $1\frac{1}{2}$ lbs. water into steam requires 1449 units.

To raise $1\frac{1}{2}$ lbs. of steam to 2250° requires 1067 units, the specific heat of steam being ·474.

The sum of these units, which expresses the calorific energy expended upon the material, not allowing for losses by radiation, is

Latent heat of carbon, . . .	5908	units.
To raise 1 lb. of carbon to 2250°, .	540	"
To convert $1\frac{1}{2}$ lbs. water into steam, .	1249	"
To raise the steam to 2250°, . .	1067	"
Total calorific energy expended, .	8974	"

The hydrogen liberated is ·166 lb., and the available units developed in its combustion, after allowance for latent heat, are $53{,}800 \times {\cdot}166 = 8932$; so that the energy of reunion is, as was to have been expected, equal to the calorific power expended in dissociation.

But it must be observed that the hydrogen does not reunite with the oxygen which it had given up to the carbon, but with a new equivalent of oxygen furnished without cost from the atmosphere, and the carbonic oxide takes another equivalent of oxygen from the atmosphere, and in burning to carbouic acid develops as many additional units as the hydrogen; so that the hydrogen and carbonic oxide from one pound of carbon in water gas would develop about 18,000 units, while under the most favorable circumstances, as in generating steam, solid coal does not generally furnish more than 9000 units per pound.

A simple illustration of the calorific power of water gas, as compared with the hydrogen and carbon of its constituents, can be given thus: 1 lb. of hydrogen unites with 8 lbs. of oxygen, forming 9 lbs. water, and develops in combustion 62,200 units.

By contact with carbon at a proper temperature the 8 lbs. of oxygen unite with 6 lbs. of carbon, forming 14 lbs. of carbonic oxide, which develops 4443 units per lb., or a total of 62,200 units.

The water formula is H_2O and carbon C. Dissociation produces H_2 and C.O. By taking oxygen from the atmosphere it becomes

H_2+O, which develops 62,200 units,
and $C.O+O$, " " 62,200 units.

And the combustion of the two gases develops twice the 62,200 units of the original H_2O, or 124,400 units.

The carbon used in the production of the water gas was 6 lbs., and the maximum calorific energy of combustion of carbon theoretically would be 14,300 units per lb., or 85,800 units for 6 lbs., which is greatly below the 124,400 units theoretically developed in the combustion of the gases.

For all operations requiring high temperature, the differences are

much greater in favor of water gas, both as regards quantity and intensity of calorific power utilized.

Dr. Prideaux has stated that at very high temperatures, as at the welding heat of iron, only one sixty-fourth of the theoretical calorific power of the coal is utilized.

These remarks are applicable only to a theoretically pure water gas composed of equal volumes of hydrogen and carbonic oxide. Such a gas cannot be produced practically in furnaces or cupolas, which is the ordinary mode of making water gas, and for two reasons, viz.:

1st. The introduction of air to secure the combustion of the coal necessary adulterates the gas with a large percentage of nitrogen.

2d. The direct contact of steam with the incandescent coal where there is no external application of heat, necessarily reduces the temperature and causes the formation of carbonic acid instead of carbonic oxide.

To correct an erroneous impression in regard to the temperature at which carbonic acid is formed, it is proper to state that vapor of water is dissociated by heat alone at a temperature of about 4500° Fahrenheit, and carbonic acid at a temperature of about one-half, or 2200°. Consequently carbonic acid cannot be formed, nor, if previously formed, can it continue to exist at this temperature. It follows, therefore, as a necessary consequence, from these positions, that a pure water gas, free from nitrogen and carbonic acid, can only be produced in close retorts, the temperature of which must be maintained with uniformity above 2000°, and this last condition requires that the gas itself, under constant volume and pressure, should be used as fuel, which is, moreover, the most economical arrangement possible.

Certain interesting facts in connection with the dissociation of aqueous vapor and the calorific power of carbon should be noted in this connection.

The calorific power of carbon is given at	14,500 units.
If to this be added the latent heat of carbon,	5,908 "
The sum is	20,408 "

which represents the total theoretical calorific power of solid carbon.

We have seen that 6 lbs. of carbon converted into water gas develops in combustion 124,400 units, which is 20,733 units per pound; so that by converting solid carbon into water gas the combustion develops the full theoretical power of the fuel, including the 6000

units rendered latent in effecting the change of condition from the solid to the gaseous state.

The elements of water are dissociated by heat alone at a temperature of about 4500°, but in the presence of carbon the dissociation is effected at one-half this temperature, and at about the same temperature carbonic acid is dissociated and cannot exist as such, so that the affinity of oxygen and carbon accomplished a result which, without the presence of carbon, would require 2200° of increased temperature.

In this connection a very interesting fact can be demonstrated, which is, that although in the presence of carbon the vapor of water is dissociated at a temperature only half as intense as is required by heat alone, yet the calorific energy required to effect the separation is precisely the same in both cases.

Dissociation of vapor of water.

H_2O is dissociated by heat alone at	4500° F.
In contact with C at about half or	2500°.

One pound of carbon requires $1\frac{1}{2}$ lbs. water to furnish oxygen for conversion to carbonic oxide. To raise $1\frac{1}{2}$ lbs. of water from 60° to 4500° requires calorific units as follows:

From 60° to 212° = 152°; $152 \times 1\frac{1}{2}$,	= 228	units.
There become latent in conversion of water into steam,	1449	"
From 212° to 4500° = 4288°; specific heat of vapor ·474, and $\cdot 474 \times 4288 \times 1\frac{1}{2}$,	= 3654	"
Heat units required to dissociate $1\frac{1}{2}$ lbs. H_2O	= 5331	

In contact with carbon, $1\frac{1}{2}$ lbs. water raised to 2250°, by calculation similar to the above, will be found to require 3126 units. And the pound of carbon will require to raise temperature to 2250° (the specific heat being ·2411) $2250° \times 2411 =$ 543 units.

To convert one pound solid carbon into gas (latent heat),	5908	"
Add heat required to raise water to 2250°,	3126	"
	9597	

But one pound of carbon, in uniting with $1\frac{1}{3}$ pounds of oxygen to form carbonic oxide, develops 4300 units, which must be placed to the credit of the account, leaving 5277, which is practically equal to the calorific power required to dissociate H_2O by heat alone, with double the temperature as shown above.

Comparison of water gas with Siemen's gas.

If the oxygen required for the conversion of carbon into carbonic oxide be derived from *air* instead of *water*, the results are widely different.

The carbonic oxide from the same weight of carbon will, of course, be equal in volume, and will possess the same calorific energy as in water gas, but instead of being re-inforced by the liberated hydrogen, which doubles its power, it is diluted and burdened by the released nitrogen, which robs it of a large proportion of its calorific power, as will be shown.

One pound of carbon unites with $1\frac{1}{3}$ pounds of oxygen, producing $2\frac{1}{3}$ pounds carbonic oxide, and develops in combustion $2\frac{1}{3} \times 4300 =$ 10,033 units. One and a third pounds of oxygen taken from the air liberate $1\frac{1}{3} \times \frac{77}{23} = 4{\cdot}5$ pounds of nitrogen, nearly, and this nitrogen, adding to the weight of the products of combustion, diminishes largely both the intensity of combustion and the calorific power of the gas. But this statement is entirely too favorable, and does not fully exhibit the waste of energy from the production of Siemen's gas.

Siemen's gas is produced in furnaces to which air is admitted, and this air supplies the oxygen required for the production of the carbonic oxide. It necessarily follows that there is a loss of heat by escape through the flues of the furnace and by radiation, which has been estimated at from 25 to 50 per cent. If this loss be estimated at only 25 per cent., it will leave 75 per cent. of the fuel to be converted into gas.

In a report of Dr. Moore, dated Jan. 22d, 1878, the composition of Siemen's gas is given:

Nitrogen, ...	0·7140
Carbonic acid, ...	0·1053
Carbonic oxide, ...	0·1752
Hydrogen, ...	0·0055

Heat units utilized, 993 per pound.

From each pound of carbon deduct 25 per cent. loss, there will remain 75 per cent. converted into gas. The percentage of carbonic acid is ·1053, and as each pound of carbonic acid contains 27 per cent. of carbon, the carbon rendered useless by conversion into carbonic acid will be $\cdot1053 \times \cdot27 = \cdot0284$. The carbon contained in the carbonic oxide is 43 per cent. Therefore, $\cdot1752 \times \cdot43 = \cdot0753$. The percentage of carbon lost by conversion into carbonic acid is $\cdot0284 \times$

$100 \div \cdot 1037 = 27$, leaving 73 per cent. of gaseous carbon capable of being utilized.

If, then, 25 per cent. of the carbon in the furnace be lost through the chimney and by radiation, and 73 per cent. only of the remainder is capable of being utilized in gas, the proportion utilized in each pound will be ·55. Seventeen and a half pounds of carbonic oxide in Siemen's gas carries with it 82½ lbs. of gases which are neither combustible nor supporters of combustion; therefore the ·55 of a pound of carbon representing 1·28 lbs. carbonic oxide must carry with it 6 lbs. of useless gases.

In the combustion of 1·28 pounds of carbonic oxide ·73 pounds of oxygen are required, and assuming that no more air is supplied than the exact amount which will suffice to furnish the oxygen, the quantity of air will be $\cdot 73 \times \frac{100}{23} = 3 \cdot 17$ pounds.

It appears, therefore, that 1 pound of carbon in a Siemen's furnace will furnish, after deducting losses, 1·28 pounds of carbonic oxide, carrying with it 6 pounds of nitrogen and carbonic acid, and requiring for combustion 3·17 pounds of air, making the total weight of the products of combustion 10·45 pounds.

If the carbonic oxide is to be used for heating other substances at a temperature of 2000°, the quantity of heat available for this purpose from 1 pound of coal can be determined as follows: 1 pound of coal yields, after deducting losses as above stated, 1·28 pounds carbonic oxide. 1·28 pounds carbonic oxide developes $1 \cdot 28 \times 4300 = 5504$ units. The specific heat of the gases being ·23 on an average, $10 \cdot 45 \times \cdot 23 \times 2000^\circ = 4807$, leaving only the difference, or 697 units, available for doing work at the assumed temperature of 2000°.

Notwithstanding the fact that the theoretical calorific power of carbon is 14,300 units, and that only 697 units, or 5 per cent., would appear from these figures to be utilized at a temperature of 2000°, the use of this gas is known to be more economical than the direct use of solid coal in metallurgy, a fact which is due to the more advantageous application of gaseous fuel.

Compare these results with those produced from the combustion of an equal quantity, 1 pound, of carbon converted into water gas. One pound of carbon produces 2⅓ pounds of carbonic oxide and ·166 of hydrogen.

The combustion of these gases requires 2·666 pounds of oxygen, furnished by 11½ pounds of air.

The products of combustion are

3·66 pounds of carbonic acid,	specific heat, ·2479
1.5 pounds vapor of water,	specific heat, ·4740
2·85 pounds nitrogen,	specific heat, ·2440

To raise these products of combustion to a temperature of 2000° requires 7539 units. The units developed by the combustion of one pound of carbon in water gas is

2·33 pounds carbonic oxide × 4300 =	10,033
·166 pound hydrogen, less latent heat of steam,	9,000
	19,033
Deduct 20 per cent. required for fuel,	3,800
	15,233
Units required to raise temperature of products of combustion to 2000° =	7,539
Leaves available for work above 2000°,	7,694

As the number of units of heat available for work with the Siemen's gas from one pound carbon at the same temperature, 2000°, was 697, it appears that the surplus calorific power above 2000° derived from a given weight of carbon converted into pure water gas, should be eleven times as great as that of an equal weight of coal in Siemen's gas. At higher temperatures, as at a welding heat, the differences will be still greater.

It is this surplus calorific power above 2000° that constitutes the chief efficacy of fuel where high heats are required, and while it is impossible to secure a high heat with a fuel of low power, it is always possible with a fuel of high power, by reducing quantity in proportion to work to be done, to obtain any desired temperature below the maximum and without waste by dilution with incombustible gases.

Comparative Intensities of Combustion.

It is usual to estimate the intensity of combustion by dividing the number of heat units developed per pound of combustible by the total weight of the products of combustion multiplied by their specific heat, but Mr. J. P. Gill has shown that such computations are erroneous except in cases where the fuel is burned without doing any work. Where work is done, as in heating other bodies, the temperature is

reduced, as the divisor must be increased by adding the product of the weight of the body heated into its specific heat.

The intensity of combustion of coal, Siemen's gas and water gas will be compared in two ways; first, by assuming that the fuel is burned and no work done, and, second, that the work of one pound of combustible is to heat one pound of water or its equivalent, 9 pounds of iron, the specific heat of iron being one-ninth that of water, nearly.

It will also be assumed that solid carbon requires for complete combustion double the quantity of air necessary to furnish the oxygen for chemical combination, while gaseous fuel can be consumed with very slight excess.

One pound of carbon requires $2\frac{2}{3}$ pounds of oxygen, which are contained in 11·6 pounds of air without excess, or 23·2 pounds with allowance.

The specific heat of air is ·2377, and $\cdot 2377 \times 23\cdot 2 = 5\cdot 52$.

If one pound of carbon develops 14,300 units,

$$\text{Then } \frac{14300}{5\cdot 52} = 2400^\circ \text{ when doing no work,}$$

$$\text{and } \frac{14300}{1 + 5\cdot 52} = 2190^\circ \text{ when heating one pound of water.}$$

One pound of Siemen's gas, according to Prof. Moore, develops 996 units, and consists of 18 per cent. carbonic oxide and 82 per cent. carbonic acid and nitrogen. ·18 carbonic oxide requires $\cdot 18 \times \frac{4}{7} =$ ·1 pound of oxygen contained in ·43 pound of air.

The weight of the products of combustion will be 1·43 pounds, the average specific heat ·23 and the product $1\cdot 43 \times \cdot 23 = \cdot 329$. The temperature of combustion heating one pound of water will be $996 \div 1 + \cdot 329 = 749^\circ$, and the temperature if no work be done $996 \div \cdot 329 = 3000^\circ$.

Intensity of Combustion of Water Gas.

Water gas contains by weight 6·66 per cent. of hydrogen and 93·3 per cent. of carbonic oxide. One pound of hydrogen requires eight pounds of oxygen; ·0666 pound requires ·5228 pound of oxygen. The weight of the resulting vapor is ·6 pound, the specific heat ·474 and the product $\cdot 6 \times \cdot 474 = \cdot 2844$.

One pound of carbonic oxide requires for combustion $\frac{4}{7}$ of a pound of oxygen; ·9304 pound requires ·5334 pound. The weight of the product will be 1·4668 pounds. The specific heat of carbonic acid is

·217, and 1·4668 × ·217 = ·3183. The whole quantity of oxygen in combustion was 1·0662 pounds, and the nitrogen mixed with it was 1·0662 × $\frac{77}{23}$ = 3·57 pounds. The specific heat of nitrogen is ·2438, and the product 3·57 × ·2438 = ·87. The sum of these products, ·2844 + ·3183 + ·87 = 1·47.

The heat units developed in the combustion of one pound of pure water gas, after deducting for the latent heat of the steam produced by the hydrogen combinations, is 7645 units.

Then, if one pound of gas is used to heat one pound of water, the temperature will be 7645 ÷ (1 + 1·47) = 3100°.

And if no work is done, 7645 ÷ 1·47 = 5200°.

The comparative intensities of combustion, therefore, when one pound of combustible is employed to heat one pound of water or nine pounds of iron will be

Coal, ...	2190°
Siemen's gas, ...	749°
Water gas, ...	3100°

And when burned without work the comparison stands,

Coal, ...	2400°
Siemen's gas, ...	3000°
Water gas, ...	5200°

It is to be observed that there are no reliable instrumental means of practically determining very high temperatures, and all the theoretical computations are based on the hypothesis that the specific heat of bodies remains constant. It is an established fact, however, that specific heats are variable, and the law of variation has been determined only within narrow limits and for a few substances. The specific heat of iron at 500° is different from its specific heat below 212°.

A recent paper submitted to the French Academy of Sciences by M. Violle states that the specific heat of iridium increases regularly with the temperature, and gives 1950°C. of the air thermometer as the point of fusion. The specific heat of gold varies up to 600°, and then gradually increases toward the point of fusion, 1035°C.

It is probable that the increase of specific heat with increase of temperature is general, if not universal, with all refractory bodies, and this fact tends to impair confidence in the method of determining temperatures by plunging a heated ball of platinum or other substance in water and noting the rise of temperature which it causes. If the spe-

cific heat at high temperatures is increased, the ordinary computation would give a result in excess of the true degree, as the specific heat is a factor in the divisor.

Another interesting comparison may be given. Siemen's gas develops 996 available units per pound, and one pound of coal produces five pounds of gas; therefore,

1 lb. of carbon	in Siemen's gas furnishes calorific power	4980	units.
1 " "	in coal utilized in evaporating water,	9000	"
1 " "	in water gas furnishes	15233	"

after deducting the gas required for fuel.

The above calorific power can only be approximately utilized at low temperature, and as the temperature increases the differences are greatly more in favor of the fuel of highest power.

It must be observed also that it is only at very low temperatures that so large a portion of the calorific power of solid carbon as 9000 units can be utilized. With exceptionally perfect apparatus and good firing it is claimed that 12 pounds of water have been evaporated at 212° with one pound of combustible. This gives over 11,000 units out of a theoretical maximum of 14,300, but in metallurgy only a small percentage of this theoretical power can be utilized.

From notes taken of statements of prominent iron and steel manufacturers during a recent visit to Pittsburg, it appears—

Puddling requires one pound of fine coal to one pound of iron. To heat one pound of iron to 2700°F. requires 300 units. The proportion of calorific power of coal utilized is in this case 1 to 40, or 2½ per cent. Another manufacturer uses 40 bushels of coal to puddle one ton. The proportion here is 1 to 56, or less than 2 per cent. In heating iron for spike mill the proportion utilized was 1 to 30, or over 3 per cent. In blast furnace, heated to 3600°, the proportion was 1 to 45, or 2¼ per cent.

Natural gas is used at the Etna and Sligo works.

The president of the gas line states that 3500 cu. ft. of gas are equivalent to 35 bushels of coal.

The calorific units in one cu. ft. coal gas are	557
" " " water gas are	427
" " " natural gas are	500
" " 35 bushels of coal	35,000,000
" " 3500 cu. ft. of natural gas	1,750,000

From which, if the statement be correct, it follows that a given amount of calorific power in the form of gas is twenty times as efficient in heating iron as an equal number of units in solid coal.

It is claimed that, notwithstanding the great waste in heating the nitrogen and carbonic acid of Siemen's gas, that its use saves two-thirds of the fuel as compared with coal in steel works.

It follows, from these facts and figures, that if water gas can be produced conveniently and cheaply it would be greatly superior to any other combustible, except perhaps natural gas, in all the essentials of quantity and intensity of heat and in economy of fuel. This result has been accomplished, and the plan for its utilization is of a very inexpensive character as compared with that which is in general use.

Water gas manufactured in cupolas and furnaces is now used successfully in Europe in metallurgy. The defects of this system have already been stated. It is simply impossible to obtain a uniform result with varying conditions; the furnaces must be heated by the admission of air, which introduces nitrogen, and unless the temperature is high, carbonic acid, instead of carbonic oxide, will be produced.

Carbonic acid being dissociated at 2200° cannot exist at or above that temperature; but when steam is admitted to a furnace it soon extinguishes the fire, and tests made in 1877 by Dr. Cresson, of Philadelphia, of numerous samples of so-called water gas, proved that there was no water gas in any of them, the heat of the furnace not having been sufficient to decompose steam. Gill's patents cover the only successful apparatus for producing water gas, by decomposing superheated steam in retorts from which air is excluded and maintaining a uniform temperature around the retorts sufficient to prevent the formation of carbonic acid by using the water gas itself as fuel.

The most perfect system possible would be to generate the gas in retorts, using the gas itself as fuel and supplying the carbon in fluid or vapor. Where pipe lines to the seaboard furnish cheap petroleum for fuel, this system can be carried out in its perfection. With regular feed of steam and hydrocarbon vapor, and uniform temperature from a gas fire, the production would be constant and the composition invariable. The labor of the retort house would be reduced to almost nothing; the feed, when once regulated, would require no changes, and no purification of the gas would be needed even for illuminating purposes.

Water Gas from Petroleum, using Gas as Fuel.

Suppose crude petroleum be used instead of coal in retorts, what will be the result as regards economy and character of product?

Sixteen pounds carbon and 24 pounds of water produce 1000 cubic feet of water gas.

If carbon is furnished by petroleum, an additional quantity of hydrogen will be liberated.

The composition of light crude petroleum from Pennsylvania is, carbon 82, hydrogen 14·8, oxygen 3·2.

The oxygen, 3·2, would neutralize $\frac{3\cdot2}{9} = 0\cdot36$ of hydrogen, and leave $14\cdot8 - 0\cdot36 = 14\cdot44$ hydrogen.

The proportion of hydrogen with 16 pounds carbon is $82:16::4\cdot44:2\cdot82$ and $2\cdot82 \times 190 = 536$ cubic feet.

Sixteen pounds carbon and 24 pounds water give

37·34 lbs. carbonic oxide = . .	523 cu. ft.
2·66 " hydrogen = . .	508
Add 2·82 hydrogen liberated from petroleum, .	536
42·82 lbs.	1567 cu. ft.

Hydrogen	by weight 12·8 per cent.,	carbonic oxide	87·2 per cent.
"	volume 66·6 "	" "	33·3 "
Cubic feet per pound, . . .			36·5
Specific gravity, . . .			·364

If 16 pounds of carbon are contained in 1567 cubic feet of gas, the quantity of carbon in 1000 cubic feet will be 10·2, and if 82 pounds carbon are contained in 100 pounds of petroleum, the quantity of petroleum to furnish 10·2 pounds or 1000 cubic feet of gas will be 12·4 pounds, and at 6½ pounds to the gallon this will be a little less than 2 gallons.

Oil at 2½ cents per gallon will be 105 cents per barrel, and with pipe lines for transportation this will be a fair price.

At this price the petroleum for 1000 cubic feet of gas will cost 5 cents, or, allowing for gas for fuel, 6¼ cents.

The calorific power of this gas, allowing for latent heat of steam,

$$\cdot128 \times 53{,}000 = 6{,}784 \text{ units}$$
$$872 \times 4{,}320 = 3{,}767$$
$$10{,}551$$

Water gas from coal, at 4 cents per 1000 cubic feet, contains, after deducting for latent heat of steam, 7577 units, and in proportion to calorific power is equivalent to petroleum gas at $5\frac{1}{2}$ cents, so that petroleum gas would appear to be $\frac{3}{4}$ of a cent per 1000 feet more expensive, but considering the fact that petroleum can be fed continuously without opening the retorts, that the changes of temperature and production of carbonic acid can be avoided or greatly lessened, and the higher calorific power will also give higher intensity in doing work, the actual economy may be in favor of petroleum water gas at $1.05 per barrel, as compared with coal water gas at $3 per ton.

It has been seen that 12·4 pounds petroleum will produce 1000 cubic feet of gas. After allowing for the oxygen there will be 10·168 pounds carbon and 1·8 hydrogen, having a theoretical calorific power of 240,783 units. The 1000 cubic feet of gas, weighing 27·3 pounds, at 10,557 units to the pound, will develope 288,042 units, the additional calorific power having been contributed by the hydrogen of the decomposed steam.

Intensity of Combustion of Petroleum Water Gas.

It has been shown that one pound of this gas contains ·128 hydrogen and ·872 carbonic oxide. ·128 pound hydrogen requires $\cdot128 \times 8 = 1\cdot024$ pounds oxygen, furnished by $1\cdot024 \times \frac{100}{23} - 4\cdot4$ pounds air, carrying 3·376 pounds nitrogen.

The products of this combustion are 1·152 pounds vapor of water, specific heat ·474, and 3·376 pounds nitrogen, specific heat ·244.

·872 pound carbonic oxide requires for combustion $\cdot872 \times \frac{4}{7} = \cdot512$ pound oxygen, contained in 2·2 pounds of air, carrying 1·688 pounds nitrogen.

The products of combustion multiplied by specific heats are

1·152	pounds	water vapor × ·474 =	·546
5·064	"	nitrogen × ·244 =	1·236
1·384	"	carbonic acid × ·2164 =	·299
7·600			2·081

One pound of this gas developes 10,551 units, and if burned in just sufficient air to furnish oxygen, the temperature would be $\frac{10551}{2.081} =$ 5070°.

If 1 pound of gas be required to heat 1 pound of water, or 9 pounds iron, the temperature would then be $\frac{10551}{3.081} = 3420°$.

Water Gas from Naphtha.

If naphtha be used instead of petroleum the quantity of hydrogen will be still further increased. The specific gravity of the gas will be reduced and also the percentage of carbonic oxide.

If a spirit be used having a boiling point 126°F., composition $C_{11}H_{26}$ (old style), percentages 71·74 carbon and 28·26 hydrogen, the quantity of hydrogen combined with 16 pounds carbon and liberated in the formation of water gas would be 71·74 : 16 :: 28·26 : 6·2 and $6{\cdot}2 \times 190 = 1178$ cubic feet.

The water gas formed from the 16 pounds carbon is as previously found

37·34	pounds	carbonic oxide,	523 cu. ft.
2·66	"	hydrogen,	508 "
6·20	"	hydrogen from naphtha,	1178 "
46·2	"	gas =	2209 "

Proportion of hydrogen by weight 19·2,	carbonic oxide	80·8
" " volume 76·3,	" "	23·7
Cubic feet to one pound,		48
Specific gravity,		·277
Calorific power per pound, less latent heat,		13,700 units.

Water Gas by the Lowe, Strong and other Furnace or Cupola Processes.

It is impossible to give with any accuracy the composition of this gas, for the very obvious reason that it has no uniform composition. Where steam is admitted to a furnace containing heated coal the effect is to reduce temperature and in a short time to extinguish combustion. In no two successive minutes can the product be the same.

Reference has already been made to the report of Dr. C. M. Cresson, of Philadelphia, who analyzed samples of water gas, so called, taken from premises of consumers in Trenton, Manayunk and Columbia, in which no water gas was found in any of them, but Prof. Moore gives an analysis of a sample which, as it is published in the pamphlets issued by parties interested in the Lowe and Strong processes, may be considered a favorable presentation. This report gives the analysis as follows:

Oxygen,	·0174
Carbonic acid,	·0637
Nitrogen,	·0880
Carbonic oxide,	·7097
Hydrogen,	·0747
Marsh gas,	·0465

Eighty-two per cent. of these gases are combustible; the balance, 18 per cent. are not only incapable of burning or of supporting combustion, but diminish the heating power of the combustible gases. The hydrogen is only 7½ per cent. by weight, while in the Gill gas, from naphtha, the proportion is 19·2 per cent.

Even with these drawbacks the Strong water gas is greatly superior in calorific power and intensity to the Siemen's gas, but the Gill water gas is superior to the Lowe and Strong, and costs only half as much when produced from anthracite coal, or coke, and water with the gas itself as fuel.

Gill Hydrogen Gas.

All gases produced either wholly or partially from the decomposition of water are called water gases, and when coal or coke are used to effect the decomposition, the resulting gas, if pure, consists of equal volumes of carbonic oxide and of hydrogen.

Where the carbon required to effect the decomposition of the water is supplied by naphtha or petroleum the proportion of hydrogen is increased and the carbonic oxide is diminished.

Although an eminent chemist declared, in a report made in 1877, "*there is no known practical method of removing carbonic oxide from illuminating gas,*" J. P. Gill had, before this time, discovered and patented processes for removing the whole or any portion of the carbonic oxide, and of replacing it by an equal volume of hydrogen, so that the resulting gas could be absolutely or commercially pure hydrogen, or could contain such portion of hydrocarbon or carbonic oxide as would give a proper specific gravity for use for illuminating purposes, both specific gravity and candle power being controllable at pleasure. The additional cost of removing the carbonic oxide entirely is covered by about four cents per thousand cubic feet, but entire removal for most purposes is neither necessary nor desirable.

XXII.

ON THE GOTHARD RAILROAD.

By CHAS. E. BILLIN, Member of the Club.

Read December 20th, 1879.

The progress of work upon this railroad, especially in the great tunnel, is of interest to all engineers, and it is to be presumed that the majority of members of the profession are acquainted with the principal facts in regard to the work. The societies of engineers of both England and France have taken much interest in the progress of work on this railroad, which will be, when finished, so great a monument to engineering skill and perseverance. Several papers, of much value and interest, giving details of the work, have been read before the foreign societies, but as yet only brief notices have been published in this country.

The principal work on the line of the road is the great St. Gothard Tunnel, and though the notes which I have gathered, and wish to embody in this communication to you, refer principally to this portion of the work, there are nevertheless a few points, in connection with the location and construction of the remainder of the road, from which valuable and interesting information may be gathered.

The project of building a railroad over the St. Gothard was first proposed about 1845. Accurate surveys for an alpine railroad were made from 1850 to 1860, and the idea of a great tunnel between Goeschenen and Airolo was then first started by Herr Müller, a Swiss engineer. Further examinations of the route were made by both Italian and Swiss engineers, and in 1869 Germany also took an active interest in the project. Owing to the Franco-Prussian war, a treaty between these three powers, to determine a basis upon which the enterprise should be carried forward was not concluded until 1871. The organization of the St. Gothard Railroad Company was immediately carried out, and on August 7th, 1872, a contract was made with M. Favre for the completion of the great tunnel.

The location of the line between Brünnen and Biasca involved many very intricate problems. A map[1] showing the position of this portion and giving some of the details of topography and location has been

[1] Plate X.

prepared by reduction from the beautiful topographical map published by the Swiss government, and very kindly presented to the Club by Mr. J. Kauffmann.

The tunneling of St. Gothard is only a portion of the immense works necessary for the completion of this Swiss-Lombard line. As far as Brünnen, on the Lake of Luzern, the difficulties encountered are only such as are met in ordinary railway construction. Beyond this point, however, the line is a succession of works almost without parallel. The northern shore of the lake from Brünnen to Fluelen is bold and precipitous. The location of the line here was one of extreme difficulty and necessitated numerous viaducts of greatest daring, windings where the roadway is almost suspended over the lake, tunnels which even after that of St. Gothard are very considerable, and all in the grandest, most picturesque situations.

From Fluelen to Goeschenen, at the northern extremity of the great tunnel, the line follows the narrow valley of the Reuss. In the lower portion of this valley the work is comparatively light, but from Amsteg up to the tunnel the valley is narrow and steep, with precipitous mountain sides, and the location of the line was very difficult. Owing to the fact that the ascent of the valley was more rapid than could be overcome by the maximum allowable grade, and that there are no lateral valleys into which the line could be run to gain distance, it was decided to excavate helicoidal tunnels in the mountain sides. This being the best method by which the necessary distance could be obtained. South of the great tunnel this same plan has been followed in making the descent. Tunnels Nos. 19, 22 and 26 on the Swiss side, and Nos. 34, 37, 41 and 43 on the Italian side, are of this nature. In tunnel No. 34 the line crosses itself while in the mountain, as shown on the map (Plate X).[1]

I regret exceedingly my inability to furnish you with a profile of the entire line.

The grades are naturally very heavy, but Switzerland is, *par excellence*, the country of steep grades and daring railway projects. Among these might be mentioned the Rigi Railway, that of Utliberg, near Zurich, which is operated by means of the ordinary adherence of locomotives with six small coupled wheels, and on which the maximum grades are 7 feet to the 100, with curves of 435 feet radius.

The maximum grade on the St. Gothard line is 2·7 feet to 100—142·56 feet to the mile—and the minimum radius of curvature between

[1] See also p. 84.

Amsteg and Biasca is 918 feet. The ordinary minimum radius is 984 feet.

The number of tunnels on the line of the road, between Brünnen and Biasca is forty-three. Their location is shown on the map (Plate X) by numbers corresponding to those in the following list, which gives the length of each tunnel:

		Metres.	Feet. Ins.
1	Gätsch,	108·5	355·11
2	Mythenstein,	32·5	106· 8
3	Hochfluh,	577·5	1894· 7
4	Franziskusbach,	196·0	642· 8
5	Oelberg-Schieffernech,	1934·0	6344· 6
6	Stutzeck,	984·5	3229· 9
7	Tellsplatte,	170·0	558· 0
8	Axenberg,	1115·0	3657· 3
9	Sulzech,	124·0	408· 6
10	Windgälle,	172·0	564· 6
11	Bristlain,	652·0	2138· 6
12	Inschi,	78·0	256· 3
13	Zgraggent,	55·0	176· 5
14	Breiten,	48·0	157· 6
15	Meitschlingen,	53·0	173·10
16	Marchlisbach,	34·0	111· 6
17	Hägriger,	29·0	95· 1
18	Muren,	48·0	157· 6
19	Pfaffsprung (helicoidal),	1487·0	4877· 0
20	Kuchberg,	305·0	1000· 5
21	Lower Entschigthal,	47·0	154· 2
22	Wattingen (helicoidal),	1090·0	3575· 0
23	Lower Rohrbach,	220·0	721· 7
24	Middle Entschigthal,	61·0	200· 3
25	Strahlock,	38·0	124· 8
26	Leggistein (helicoidal),	1095·03	3591· 6
27	Mayen-Kreuz,	77·0	253· 0
28	Upper Entschigthal,	98·0	321· 3
29	Rohrbach-Naxberg,	1563·0	5126·10
30	Gothard,	12360·5	48,887· 0
	Carried forward,	24,852·53	89,861· 6

	Metres.	Feet. Ins.
Brought forward,	24,852·53	89,861· 6
31 Stalvedro,	190·0	623· 0
32 Dazio,	347·0	1138· 3
33 Artoito,	71·0	233· 3
34 Upper helicoidal tunnel, near Dazio,	1557·0	5107· 0
35 Monte Piottino,	138·0	452· 8
36 Pardorea,	282·0	924· 7
37 Lower helicoidal tunnel, near Dazio,	1556·0	5103· 9
38 Boscerina,	42·0	138· 0
39 Polmengo,	275·0	902· 5
40 La Lune,	441·3	1446· 8
41 Piano Tondo (helicoidal),	1551·0	5087· 3
42 Tonruiquet,	72·0	236· 6
43 Travi (helicoidal),	1494·5	4901· 9
Total,	32,869·33 =	116,156· 8

This is a total of 32,869·33 metres of tunneling in 107·360 kilometres, or 116,156 feet 8 inches in 66⅔ miles.

The St. Gothard Tunnel is the only portion of the line which is at present being constructed for double track. In building the other tunnels, which must in future be made for two tracks, they use what is known as the Pressel-Kauffmann profile. The original cost of tunnels constructed with this profile is but slightly greater than if ordinary single track profile were used, while the tunnels can afterwards be enlarged much more easily, at a smaller cost, and without seriously interfering with traffic or the operation of the road.

Plate IX, Fig. 1, shows the Pressel-Kauffmann profile for solid rock. The tunnel is the same height as full-sized double-track tunnel, 7 metres from base of rail, and in enlarging the only work necessary is to take out the sides to full profile. Fig. 2 represents the adaptation of this same profile to loose rock, the top of the tunnel being arched with full-sized arch. When enlarging, the sides are taken out, and side walls built down to support the arch. Fig. 3 shows double track profile, which is used in bad rock or earth, and has the Pressel-Kauffmann profile dotted in to show comparison. The following table gives the quantities in the three profiles:

Areas of Tunnel Sections.

	Fig. 1. Sq. metres.	Fig. 2. Sq. metres.	Fig. 3. Sq. metres.
Excavation,	34·150	37·856	60·603
Clearing,	31·695	30·542	44·280
Area of drain,	0·075	0·075	0·075
Arching,	——	3·809	3·809
Abutments,	——	——	6·456
Masonry for drain,	0·180	0·180	0·180
Flag covering of drain,	0·075	0·075	0·075
Dry back filling,	——	1·050	2·050
Ballast,	2·125	2·125	3·675
Total masonry,	0·180	3·989	10·445

The St. Gothard Tunnel.

The greater portion of the tunnel is on a tangent, the direction being about 176°. A section of 148·0 metres (486 feet) at the southern or Airolo end is on a curve of 299·8 metres (984 feet) radius. The length of the tunnel on tangent is to be 14,752 metres (48,411 feet), which, with the curved portion, makes a total length of 14,900 metres (48,887 feet). In order to verify the centre line of the tunnel with great accuracy the tangent portion was extended for 541 feet at the Airolo end by what is called an "alignment tunnel."

The elevation of grade at the Goeschenen end of the tunnel is 1109 metres (3639 feet) above tide, and at the Airolo end is 1145 metres (3757 feet). At Andermatt, three kilometres ($1\frac{7}{8}$ miles) south of the Goeschenen end, the elevation of the surface above tide is 1450 metres (4756 feet), and 5·250 kilos ($3\frac{1}{4}$ miles) further south is the highest point over the line of the tunnel, the elevation being 2900 metres (9513 feet). The grade of the tunnel rises from the Goeschenen end at the rate of 5·92 per cent. ($31\frac{26}{100}$ feet per mile) to the centre, then runs level for 180 metres (590 feet), and falls toward Airolo at the rate of 2 per cent. ($10\frac{56}{100}$ feet per mile) until within 732 metres (2402 feet) of the southern portal, when it changes to 1 per cent. ($5\frac{28}{100}$ feet per mile). In the original plan this latter grade was intended to be used for the southern portion, but it was found expedient to increase it to 2 per cent. in order to thoroughly drain the tunnel.

A section of the finished tunnel is shown on Plate X. In the

original design the drain was situated under the middle of the roadway, but it was found to be very much more convenient in excavation and arching to locate the drain at the side, as shown. The whole length of the tunnel will probably be arched, the masonry work varying in thickness according to the nature of the rock. Under good rock the arch is built of but 40 cm. (15¾ inches) thickness; where the rock is loose or shaky 70 cm. (27½ inches) is usually employed. At about 2830 metres south of the Goeschenen end, where the rock is calcareous, very compressible and thoroughly decomposed and disintegrated, the arch was built of 1 metre thickness. This rock contained large quantities of water, which flowed off at the rate of 180 gallons per minute, and made working very difficult. During the early portion of this year the arch here showed signs of failing. Very heavy timbering was placed under it, and the arch was removed in small sections, being replaced by an arch 1·50 metres thick at the crown, and of a section as shown in Fig. 7.

Compressed air is the only motive power used in all the work connected with the tunnel, for the perforators, locomotives, in the machine shops, etc. The air compressors are all run by water-power derived from the Reuss at the Goeschenen end, and from the Tremola and Tessina at the Airolo end. The water-power of the streams in these mountains is almost beyond conception; for instance, the river Reuss in five miles above the tunnel tumbles nearly 1700 feet. A reservoir was constructed in the bed of the Reuss, a short distance above Goeschenen, and the water is led from it by a line of iron pipe 34 inches in diameter to the turbines. Basins, for the filtration of this water before use in the turbines, which were at first thought necessary, are no longer employed. The head of water available at this end of the tunnel is 279 feet, which gives 1360 horse-power at lowest water-mark.

"On the south side, it was thought, at first, that all the water necessary for working could be taken from the Tremola, a brook flowing down from the St. Gothard. At an elevation of 4544 feet above the level of the sea, the water was caught in a reservoir, and thence led to the bed of the Chiesso Brook by a channel partly lined with masonry, partly with wood, and covered. By the bed of the Chiesso, it flows to the filtering reservoir, which is 4331 feet above tide. From the latter, again, a line of cast iron pipe, 24½ inches in diameter and 2762 feet long, leads to the turbines. The available head of water here amounts

to 541 feet, the effect being 440 horse-power. In time it became obvious that the amount of water furnished by the Tremola did not, under all circumstances, suffice for the engines, and that, especially in winter, the supply often stopped altogether. The contractor, therefore, decided to use the water power of the Tessino, also; but, on account of the slight fall of this river, he was forced to catch the water about 2½ miles above Airolo, at an elevation of 4121 feet above the level of the sea, and from thence to build a canal, partly stone arched and partly of wood, 9984 feet long, of 6½ square feet cross section, 5 per cent. grade. Diameter of pipe, 2½ feet; length of line of pipe, 2229 feet; head, 295 feet. Effect may be more than 1000 horse-power."[1]

The machinery used for compressing air, consisting of turbines and pumps, has been fully described and illustrated in the *Rapports Trimestriel du Conseil Fédéral Suisse.*

There are two systems of air-compressors, both designed by M. Colladon, of Geneva,, and in both which the principle is about the same. The old-style batteries have three high-speed cylinders (16½ inches diameter, 25½ inches stroke, and 65 strokes per minute), with a Girard turbine of 8·2 feet. The air is compressed to 7 atmospheres total pressure.

The new-style batteries, two groups of which were erected at each end of the tunnel in the summer of 1876, comprise: 1st, a Girard turbine, of 16 feet 7 inches diameter, on a horizontal shaft, under a clear head of 240 feet, and yielding 325 horse-power at the shaft, by the expenditure of 1016 cubic feet of water per minute, at a speed of 70 revolutions per minute; 2d, two air-pumps, each on a frame which carries one end of the turbine shaft, the turbine being placed between the pumps. The pumps are worked by cranks and connecting rods from the turbine shaft. Each pump is 27½ inches in diameter, with a stroke of 35·4 inches (34 strokes per minute). The air is compressed to 8 atmospheres of total pressure. Each cylinder is fitted with two ingress valves and one egress valve at each end. The valves, with their cages, are of gun metal; the screws for fixing them are of steel. The injectors placed on the cylinders, for pulverizing the water are of gun metal: there are four of them to each cylinder. To insure uninterrupted service, the friction surfaces have

[1] My notes in regard to the tunnel, taken in June, 1879, refer principally to work at the Goeschenen end. Above quotation is from Mr. Henry S. Drinker's work on *Tunneling, Explosive Compounds and Rock Drills.*

SECTIONS OF ST GOTHARD TUNNEL.

Fig. 1

Fig. 2

.3.

been made large in area, and the oil cups very large; the piston rods, connecting rods and cotters are of steel. The holding down and other bolts are of iron.[1] The compressed air and cylinders are cooled by means of special appliances which admit a circulation of cold water about the cylinder, the piston and piston rod. With a minimum power of 325 horse-power at the shaft, 216 cubic feet of compressed air should be produced per minute.

Properly speaking, the above described are the compressors for the perforators. They feed into a reservoir 29½ feet long and 65 inches in diameter, outside of the tunnel, and into a supplementary reservoir, inside, close to the workings. Air is led from these by means of wrought iron pipes, which diminish in size from 8 inches in diameter at the facade to 4 inches in the heading; the tubes for connecting with the machines are 2¼ inches in diameter.

Special compressors, designed by MM. Colladon and Turrettini, and built in 1874, furnish air at 14 atmospheres total pressure for the locomotives. They do not differ from the other compressors except in the improvement of details as to the disposition of the valves, in the orifices of the injectors which throw pulverized water into the interior of the cylinder, and in reducing to a minimum the neutral spaces at the extremities of the cylinder. They can compress the air directly from 1 to 14 atmospheres without the temperature being raised more than 15 to 20 degrees. It is also possible, by a very simple arrangement, to change these compressors so as to work to 7 or 8 atmospheres, and thus augment largely the supply of air for the perforators.

There are special large reservoirs for this air, one outside and the other inside the tunnel, at a distance of 7000 feet from the entrance. The pipe used to convey this air from the compressor to the reservoirs is 2 to 2½ inches in diameter.

At the Goeschenen end, during 1878, the average pressure of compressed air used for perforating and for the ventilation of the tunnel was 6·48 atmospheres at the entrance of the tunnel, and 3·76 atmospheres at the front of the heading; the pressure of air for the locomotives was 11·57 atmospheres absolute; the loss of pressure due to friction and leakage in the pipes was smaller than in former years, the gain being due to the use of small supplementary reservoirs.

At the Airolo end the average tension of the compressed air for the

[1] Clark on "The St. Gothard Tunnel," *Minutes of Proceedings Inst. of C. E's*, vol lvii, part iii.

perforators and pumps and for ventilation was 4·70 atmospheres at the entrance, 3·37 in the heading, 8·82 in the reservoir of air for the locomotives at the entrance.

The quantity of air exhausted varies sensibly according to the amount of water which can be obtained for the motors, it being greater during the months of summer than in winter.

The following shows the variations in amounts of air exhausted by the compressors at both ends of the tunnel:

	Goeschenen. cu. m's.	Airolo. cu. m's.
Daily average in month of June, 1878,	138·000	
" " " Nov. "	58·520	
" " during summer months,	130·776	181·594
" " " winter "	104·650	122·140

At Airolo the maximum during the month of September was 207·200 cu. m., while the minimum, in the month of November, was only 92·120. In this estimate 60 per cent. is taken as the useful effect of the compressors.

The air used at the perforators and other machinery in the tunnel has proved entirely sufficient for ventilation, even in winter. During the winter months, however, the heat is much more sensible, owing to the smaller quantity of air, and this is the cause of a very notable diminution in the amount of work performed by the men. This shows what a very great economical advantage mechanical perforation and consequent good ventilation has given in the St. Gothard, as compared with what hand work would have been.

At the commencement of work on the tunnel large exhausters, bell-shaped gasometers, were built near the tunnel entrance, to exhaust the vitiated air from the workings by means of pipes, but the air used for work in the tunnel giving sufficient ventilation, these are not used.

In the finished portions of the tunnel the transportation of workmen, material and debris is effected by means of a small railway, one metre gauge, on which are employed compressed-air locomotives. These were built at Creusot, and are provided with M. Mékarski's hot-water reservoir and with M. Ribourt's automatic governor, by which steam, air or gas are wire drawn from a higher pressure that may be variable, to any constant pressure in the cylinder. The engine is placed on four coupled wheels, 30 inches in diameter and 4 feet 1 inch apart between the centres. The cylinders are 7·88 inches in diameter,

with a stroke of 14 inches. Beside an air reservoir on the locomotive, there is carried on an eight wheel truck, behind the engine, a cylindrical reservoir, 5 feet 7 inches in diameter, and 11 feet 8 inches long, having a capacity of about 260 cubic feet. This reservoir is charged with air at 14 atmospheres pressure, either at the entrance of the tunnel or from the supplementary reservoir in the tunnel. This air is wire drawn, so as to give a pressure of four atmospheres in the cylinders, or 45 pounds per square inch effective pressure. The weight of the engine is about 7½ tons.

During the prosecution of work in the tunnel, the rock drills, or perforating machines of Ferroux, Dubois and Francois, and McKean have been employed. At present Ferroux machines are used exclusively at the north end, and the McKean drill, as modified by M. Seguin in 1877, is used at the south end. The Ferroux machine consumes 85 cubic inches of air per stroke of the drill; its weight is a little less than 400 lbs., and cost about 1500 francs. The McKean-Seguin machine has a rod of 2½ inches in diameter, piston 4 inches in diameter and stroke of 4¾ inches. From 450 to 480 strokes per minute, giving a penetration of six inches in hard granite, can be made when working under pressure of one atmosphere.

"For mounting these drills, carriages were constructed which move forward on rollers and are pushed up to the point of attack on tracks in the tunnel. Each carriage will carry from six to eight drills. For every set of rock drills there are needed, on an average, one foreman, four miners, two machinists, eight helpers and one boy. After a blast has been cleared away the carriage with the drills is run up to the face. Two trucks accompany them, one carrying a tank of water and the other a number of drills. The carriage being at the face, the drills are brought into position and the carriage-wheels blocked. Connection is then made with rubber hose between the large air-pipe and a small tank at the back end of the drill-carriage. From this tank small rubber hose leads to the single drills, the air being turned on to each by cocks; water is injected into the holes under pressure of compressed air."[1]

The accompanying table has been prepared from the official report for 1878.[2]

[1] Page 278, *Tunneling*, by H. S. Drinker.

[2] *Septième Rapport de la Direction et du Conseil d'Administration du Chemin de Fer du Gothard.*

Average Monthly Results of Mechanical Perforation in the Headings during Twelve Months ending December 31st, 1878.

Elements.	Goeschenen.[1] North end.	Airolo[2] South end.	Totals.
Average cross-section of heading....sq. yds.	8·07	7·74	7·90
Monthly advance.................................feet	357·9	336·2	694·1
Average advance per day[3].................. "	12·0	11·45	23·45
Maximum advance in one day............ "	23·9	23·0	23·9
	h. m.	h. m.	h. m.
Time at work..	707 20	708 04	1415 24
" lost..	10 45	22 33	33 18
" employed in drilling........................	386 22	303 09	689 31
" " blasting, clearing away, etc...........................	320 58	404 48	725 46
	Minutes.	Minutes.	Minutes.
Average time per machine to drill 1 yard....	36·03	42·81	39¼
	h. m.	h. m.	h. m.
" " in drilling for one attack......	4 43	3 50	4 16
" " in blasting and clearing away for one attack...................	3 44	6 38	5 11
" " for completing one attack......	8 27	10 28	9 27
Number of attacks or positions of drill carriage..	86·	83·	169·
Number of attacks or positions of drill carriage for 10 feet of heading.....................	2·44	2·53	2·48
Total number of machines in service.........	332·4	406·4	738·8
Number of machines per station on carriages.................	4·0	4·47	4·23
" " changed for repairs	31·0	34·75	65·75
Proportion per cent. of machines changed for repairs..	10·63	8·97	9·8
Average number of holes per station.........	20·759	15·96	18.36
Number of jumpers changed.....................	6297·8	4161·04	10,459·2
" " " for every ten feet advance of heading............................	181·6	114·6	148·1
Number of holes drilled...........................	1780·8	1388·0	3168·8
" " " for every 10 feet advance of heading................................	50·74	40·0	45·32
Total length of holes drilled.................feet	8293·16	5830·2	14,123·36
" " " " for 10 feet advance of heading..............................feet	214·2	165·3	189·75

[1] Ferroux drill used exclusively.

[2] McKean-Seguin drill used exclusively.

[3] The average advance per day is calculated from the time actually spent in work, deduction being made for lost time. At Goeschenen, owing to time lost to permit of giving points for the axis of the tunnel, but 28 days were made in each May and December.

Elements.		Goeschenen. North end.	Airola. South end.	Total.
Length of holes drilled per shift	"	373·95	355·55	364·75
" " fired "	"	357·9	336·6	347·25
" " remaining unused per shift	"	3·9	3·9	3·9
Average gross length of each hole	"	4·3	4·16	4·23
Effective length of each hole	"	4·13	3·98	4·05
Length remaining of each hole	"	·187	·235	·211
Average number of workmen per day		1275	1666	2941
Maximum number of workmen for 1 day		1746	2145	3891
Pressure of air at the front total atmospheres	Minimum	1·33	2·33	1·33
	Average	3·61	3·45	3·53
	Maximum	6·20	5·00	6·20
Average temperature at the front while drilling		75·1°F.	78·5°F.	76·8°F.
Average temperature at the front while clearing away		78·2°F.	84·8°F.	81·5°F.

The tunnel profile, in working is divided into four principal portions. In the upper portion of the profile is the "gallery of advancement," or heading (see Plate X, profile at E), and the "battage," or enlargement of heading and widening out to full profile (Plate X, profile at D).

All the lower portion is called the "strosse," into which is cut the "cunette," or lower heading (Plate X, profile at C). On the remaining portion of the "strosse" is laid the track which leads from the gallery of advancement and the workings of enlargement. The "cunette" is attacked from its face in two benches, the material being transported by rail to the tracks in the finished portion. In order to make as much progress as possible, in taking out the "cunette," it is attacked at several other points by working down into this portion from above, as shown in longitudinal section, Plate X, at B, and then pushing work forward in three benches. These benches are used in handling material, which is thrown by hand from one bench to the next above it, and then loaded into cars at the side on top of the remaining portion of the strosse.

The present system of transportation was inaugurated about the middle of 1877, and has proved highly advantageous. The passage of material from the upper portion to grade is performed by means of an incline, at grade of 30 p. c. Below and above the incline are switches, which permit the full and empty wagons to pass. The full wagons, united in a train, descend by the incline, and soon after, the empties are pulled up by horses and distributed among the various workings

of enlargement and to the heading. From the incline to the point of discharge, outside the tunnel, the transportation of the full wagons is performed in summer by means of the air locomotives; in the winter when there is a limited quantity of compressed air, these air engines run only to the entrance of the tunnel, and from there steam locomotives haul the trains to place for discharging. When water fails in winter, the steam locomotives bring the empty wagons into the tunnel as far as 2000 metres, but from that point to the foot of the incline only air locomotives are used. Independent of the quantity of air which they receive at the entrance of the tunnel, the locomotives can be replenished from a reservoir situated at 2200 metres, and which contains 157 cubic metres, and also at the extremity of the pipe established from the reservoir to the foot of the incline.

When the "cunette" is fully taken out for a considerable distance, an incline is built, leading from it into the upper portion of the tunnel. The remaining portion of the bottom, under the old track, is then taken out, and a "cunette" pushed along the other side of the tunnel, beyond the new incline. Formerly the "cunette" was driven along one side only, and material from the upper workings was dumped into cars in the bottom; but, as under the present system it is necessary to conserve one incline until a second can be opened, it results that the "cunette," or bottom heading, is established alternately along the east and west sides.

Masonry work is completed to keep pace with enlargement. The arch is built before any of the bottom is taken out; afterwards the bottom is squared up, and the foot walls are built in. It is intended, if possible, in some portions of the tunnel, under St. Gothard proper, where the rocks consist of gneiss, granite and schist, to leave the profile unarched.

Work continues without interruption day and night. The 24 hours are divided into three shifts, workmen being transported by rail from the entrance to places of working. The work follows its course with as much quiet and as little apparent difficulty as the smallest work of the kind—they have even renounced most of the special precautions which at first seemed necessary to so great a work.

Some very interesting and useful information in regard to the terms of the original contract, estimated cost of work, the advantage of subletting, etc., are given by Mr. Drinker in his work on *Tunneling*, pp. 273 to 284.

The state of the work at the tunnel on the 20th of June, 1879, was as follows:

Gallery of Advancement.

Goeschenen side, . . .	22,947·3 feet.
Airolo " . .	20,998·4 "
Total, . . .	43,945·4 "

Completed Tunnel.

Goeschenen side, . . .	12,139·7 feet.
Airolo " . .	13,124·0 "
Total, . . .	25,263·7 "

The total length of the tunnel ought to be 48,887 feet. Therefore there only remains 23,623·3 feet of the gallery of advancement to be pierced before the workmen can shake hands. It was expected that this portion would be finished by February, 1880. The enlargement of the tunnel to finished section and the masonry work are advancing rapidly, and it is hoped that the tunnel will be entirely completed in two years.

The remainder of the line cannot be finished for at least five years. M. Favre had proposed in the interim to traverse the tunnel with trains, by means of compressed air locomotives. This would save considerable time in traveling by diligence from Fluelen to Biasca, and would, moreover, avoid the great dangers which at certain seasons of the year are encountered in crossing the St. Gothard pass.

ANNUAL REPORTS.

I. Annual Report of the Treasurer,

For the year ending January 10th, 1880.

Mr. President and Gentlemen :

I respectfully submit the following statement of the finances of the club :

RECEIPTS, 1879—1880.

Dues, 1878,	$ 12 50	
Dues, 1879,	367 50	
		380 00
Entrance fees,		185 00
Subscriptions to Proceedings,		172 29
Sales of Proceedings to members,		11 00
Advertisements,		112 00
Treasurer's receipts for year ending Jan. 10th, 1880,		$860 29
Treasurer's balance Jan. 11th, 1879,		23 05
Incidental receipts,		6 89
Total receipts,		$890 23

PAYMENTS, 1879—1880.

Publications:		
Proceedings Nos. 1, 2 and 3,	$339 79	
Constitution and By-Laws,	21 75	
Memorial to Legislature,	11 00	
		372 54
Printing Circulars, Notices, etc.,		35 99
Stationery,		23 00
Rent of Rooms,		150 00
Pay of Janitress,		14 00
Furniture,		76 84
Postage,		74 11
Expressage,		3 10
Sundries,		4 20
Total payments,		$753 78
Balance on hand,		136 45
		$890 23

Your obedient servant,

CHAS. E. BILLIN, *Treasurer.*

II. Annual Report of the Corresponding Secretary,

For the year ending January 10th, 1880.

Mr. President and Gentlemen :

In the year just past, which is the second in our history as an organization, the Club has taken several decided steps towards making itself

more permanent and useful, and better known to the world at large. In consequence, the interest of the members in the welfare of the Club has steadily increased, many valuable donations to the library have been received, and the number of scientific periodicals and transactions of engineering societies, which are received regularly, has been largely added to. Everything would seem to predict that the future of the Club will be continued activity and usefulness in the promotion of engineering science in and about Philadelphia.

One of the important changes of the year has been moving into larger, more attractive and conveniently located rooms. It is necessary that such a club as this should partake as much of a social as of a strictly professional nature, and it is hoped that in the future members will make more frequent use of the privileges of the club rooms.

The most important action taken by the Club has been the publishing of its Proceedings. Though undertaken somewhat as an experiment, the results have proved highly successful, for nothing could have given greater impetus to every interest of the Club. The labor of preparing material for press, superintending illustrations, reading proofs, and other necessary work connected with the preparation and distribution of the several numbers of the Proceedings, has been considerable and was largely borne by the Committee on Publication, to whom the thanks of the Club are due.

The first number of the Proceedings was issued in January, 1879, and contained the most important papers and communications which had been read before the Club during 1878.

Nos. 2, 3 and 4 have since been issued. No. 5, which will close Volume I, and contain the proceedings of the Club from December 6th to the end of the second year, including this annual meeting, is at present in press.

Since the last annual meeting, held Jan. 11th, 1879, the following papers have been read before the Club:

Conical Arches at South Street Bridge, Philadelphia, by D. McN. Stauffer, C. E.

Holly System of Steam Heating, by Prof. L. M. Haupt, C. E.

The Future of American Engineering. Address by Thos. C. Clarke, President.

The New River Coal Field, West Virginia, by Chas. A. Young, Geol.

Some Features of Ancient Engineering, by Geo. Burnham, Jr., C.E.

Nomenclature and Classification of Masonry, by Prof. L. M. Haupt, C. E.

Proper amount of Water-way for Culverts, by Thos. M. Cleemann, C. E., with discussion by Messrs. Darrach, Stauffer and Hering.

The Connecting Rod, by Jas. Christie, M. E., with discussion by Prof. Wm. D. Marks, M. E.

The Water Supply of Philadelphia, by Chas. G. Darrach, C. E.

Rock Salt Deposit of Huron and Bruce Counties, Ontario, Canada, by John Hy. Harden, M. E.

On Ganguillet and Kutter's Formula for the Flow of Water, by Thos. M. Cleemann, C. E.

Progress of the Geodetic Survey of Pennsylvania, by Prof. L. M. Haupt, C. E.

On an Important Legal Decision, by Percival Roberts, Jr., M. E.

On the Angular Pitch of Square-threaded Screws, by Wilfred Lewis, M. E.

On Water Gas from Coal and Petroleum, by Herman Haupt, C. E.

On the Gothard Railroad, by Chas. E. Billin.

During the same period notes or communications have been furnished by members, or by persons introduced by members, on the following subjects:

Cost of the Cleveland Viaduct.

Progress of the Madeira and Mamore Railroad, Brazil.

Iron Railway Cross Tie.

The Sand-blast Process for Sharpening Files.

The Use of Heliotropes for Signaling.

The System of Telephone Exchange.

No. 5 Turbine at Fairmount Water Works.

Schmitt's Revolving Spiral Screen.

Blocks for Sewer Connections.

The Harrison Car Axle.

Automatic Foul Air Valve.

American Portland Cement.

Eames' Petroleum Puddling Process.

No. 6 Engine at Spring Garden Water Works.

Preservation of Timber.

Butler Mine Fire Cut-off.

A New Self-plumbing Ranging Rod for Transit Field-work.

The Aneroid Barometer.

Water-way of Bridges.

The above-named papers and communications, together with minutes of meetings of the Club and of the Board of Directors, a list of contributions to the Library, names of new members, announcements, etc., have been published in Nos. 2, 3, 4 and 5 of the Proceedings of the Club. A copy of each number has been sent to the address of each member, and to the many engineering societies and publishers of technical periodicals who have expressed the desire to exchange publications with the Club.

The Club has received during the year the official publications of the following associations, in exchange for its Proceedings:

The Institution of Civil Engineers, London.

Society of Civil Engineers, London.

Imperial Technological Society, Moscow.

Essayon Club Engineers, U. S. A., New York.
Swedish Society of Civil Engineers, Stockholm.
Society of Civil Engineers, Paris.
Saxon Society of Engineers and Architects, Dresden.
Austrian Society of Engineers and Architects, Vienna.
Institution of Engineers and Shipbuilders of Scotland, Glasgow.
Association of Civil Engineers of Portugal, Lisbon.
American Institute of Mining Engineers.
American Society of Civil Engineers.
Civil Engineers' Club of the Northwest, Chicago.
Boston Public Library.
Argentine Scientific Society, Buenos Ayres.
Aeronautical Society of Great Britain.
American Iron and Steel Association.
Journal of the Society of Arts, London.
Journal of the Franklin Institute, Philadelphia.

The following magazines and journals have been contributed to the lub by publishers, or received in exchange for our Proceedings:

Annales des Ponts et Chaussées, Paris.
Van Nostrand's Engineering Magazine, New York.
Telegraphic Journal and Electrical Review, London.
Railway World, Philadelphia.
Railroad Gazette, New York.
Railway Review, Chicago.
Railway Age, Chicago.
Manufacturer and Builder, New York.
Engineering and Mining Journal, New York.
Scientific American, New York.
American Gas Light Journal, New York.
Iron Age, New York.
Metal Worker, New York.
Building News, London.
Engineering, London.
Engineering News, New York.
Army and Navy Journal, New York.
American Manufacturer and Iron World, Pittsburg.

The publication of the Proceedings has been so great an advantage the Club, in every way, that it seems most important that they ould, if possible, be maintained. It is therefore essential that there all be a good supply of valuable material for publication, and for is we must depend very largely upon the Committees on Information. members will do their whole duty when serving on these commites, they will aid very materially in maintaining the reputation of the ub before the world, and in making the meetings of interest and lue to members.

The Library has received, besides the above-enumerated transactions

and periodicals, a large number of contributions from members of the Club, authors and publishers.

During the year 311 bound volumes were received, besides numerous pamphlets, charts, maps, photographs, etc.

Members are earnestly requested to donate to the Club any engineering works, reports or pamphlets, or State, railroad or geological reports, which they may feel able to spare from their own libraries. The library of a local engineering society should be its most valuable property, and a constant source of profit to members. It depends very largely upon the exertion and liberality of individual members whether we will be able during the next year to form the foundation for a valuable engineering library in connection with the Club.

In conclusion, allow me to congratulate the Club upon its success, and to urge each member to do all he possibly can to maintain our good name, and to make the Club felt as a power for the promotion of the highest interests of the profession.

Very respectfully, your obedient servant,

CHAS. E. BILLIN, *Cor. Secretary.*

III. Annual Report of the Recording Secretary,

For the year ending January 10th, 1880.

Mr. President and Gentlemen:

With this meeting ends the second fiscal year of the Club's existence. Since the last annual meeting nineteen meetings have been held, comprising thirteen regular, four business and two special meetings, and with an average attendance of twenty members. Thirty-five visitors have been present at regular meetings, many of them having attended by special invitation, for the purpose of presenting some subject of general interest.

During the year the membership has been increased by the election of thirty-eight active and two corresponding members, while our numbers have been reduced by the loss of four members, three by resignation and one by death, leaving a total of ninety-three members of all classes.

In the death of Mr. J. B. Knight, Vice President, the Club suffered a very great loss, which need not now be further referred to, as special action was taken by the Club at the time of this sad event.

The Board of Directors have met every month during the year, with one exception, for the transaction of necessary business, but the regular meetings of the Club were discontinued between June 7th and October 4th, on account of so few of the members remaining in the city.

In June last a very kind invitation was extended to the Club by the American Society of Civil Engineers to be present at their elev-

enth annual convention, to be held in Cleveland on the 17th of June. Eleven members availed themselves of this valuable opportunity for instruction and pleasure, and returned with a sense of gratitude for the courtesy extended by the American Society of Civil Engineers, and the generous hospitality of the local committee of Cleveland gentlemen.

Printed notices of all meetings have been sent to each member, as required by the constitution, but these would be of much greater value were each chairman of the Committee on Information to report to the Secretary, when possible, any interesting paper that is to be read at the following meeting, so that this information might be included in the notice.

The increased attendance during the past three months, and the large number of recent applications for membership shows a rapidly growing interest in the Club, which, it is to be hoped, the members will endeavor to maintain. Very respectfully,

HERMAN HOOPES, *Recording Sec'y.*

IV. ANNUAL REPORT OF THE BOARD OF DIRECTORS.

For the year ending January 10th, 1880.

Gentlemen:

The reports of the Treasurer and the Secretaries so fully cover the history of the Club during the past year that the Board of Directors find it unnecessary to submit any additional remarks.

They desire, however, to congratulate the Club upon the progress made during the year, and to express their hopes that the interest which has been displayed since its inauguration may continue to grow in the same proportion as heretofore. Very respectfully,

WM. G. NEILSON,
COLEMAN SELLERS, JR.,
RUDOLPH HERING,
PERCIVAL ROBERTS, JR.,
HOWARD MURPHY,
Board of Directors.

NOTES AND COMMUNICATIONS.

A NEW SELF-PLUMBING RANGING ROD FOR TRANSIT FIELD WORK.

REGULAR MEETING, DEC. 20TH, 1879.—Prof. L. M. Haupt communicated the following:

All engineers who have had any experience in location on rough, heavily timbered ground will appreciate the efforts of Mr. Chas. S. Heller, of the firm of Heller & Brightly, and a member of the Club, to eliminate as far as possible one of the causes of inaccuracy resulting from a careless or inexperienced rodman. When, as frequently happens, the rodman is invisible and only the top of his rod shows over a ledge of rocks or through a clump of trees, and the roaring of a cataract prevents his hearing a word from the transit man, it is very important that his rod should be held vertical. To accomplish this the inventor has applied the "gimballing" principle of the plummet lamp, used in mine surveying, to the transit rod, as shown in the accompanying figure, by substituting brass for wood, making the rod hollow, loading the bottom by filling the inside of the tube with lead to a convenient height and attaching gimballs at some point above the centre of gravity. By means of these gimballs the rod is held by the assistant, and as soon as raised free from the ground it immediately plumbs itself, or, in other words, is truly vertical.

The rod which I present as a sample is seven feet in length, of a "hard brass" seamless tube, specially rolled so as to be perfectly straight, and extra heavy so as not to easily bend, having an outside diameter of $\frac{11}{16}$ and inside $\frac{7}{16}$ inch. It is divided into feet by the ordinary red and white bands, fire japanned, with brass cone and steel point on one end, and on the opposite end a drill for transferring centres into stone, etc. The *lower four feet* are filled with lead, and the gimballs are attached six inches *above* the four foot marks. Where, however, a greater length than seven feet is desirable, instead of increasing the length of the main tube, which would make it unwieldy, a small tube, fitting and sliding inside of the main tube (telescoping it as it were), allows a twelve foot length to be obtained without materially increasing the weight.

Although so slender, these rods are said to be quite as visible with the latest improved transit telescopes, which have a magnifying power of 28, as the two inch wooden rod is with the more

imperfect combination in the telescopes formerly used, and having merely a power of 10 to 12 diameters.

These rods form an important link in the improvements demanded in surveying instruments by those who desire to do conscientious, rapid and good work, and it may not be amiss to mention that their cost is but little more than that of the wooden "ranging poles" ordinarily used.

THE ANEROID BAROMETER.

REGULAR MEETING, DEC. 20TH, 1879.—Mr. Chas. A. Ashburner communicated the following:

Saturday, Nov. 30th, 1879, in company with Mr. S. B. Whiting, engineer of the Philadelphia and Reading Coal and Iron Company, and Mr. A. W. Sheafer, of Pottsville, I visited the deep workings of the company near Pottsville. We descended the east Norwegian shaft, which has a depth of 1585 feet. I carried with me a Hicks (London) barometer of 3000 feet graduation, imported for me by Jas. W. Queen & Co. About four minutes was consumed both in the descent and ascent. In descending, the barometer recorded a depth of 1590 feet, and came to its bearing in about 20 seconds after the bottom of the shaft was reached. We remained in the workings three-quarters of an hour, in which time the barometer showed a change of only 10 feet. In ascending, the aneroid indicated a height of 1575 feet, and came to its bearing in about a quarter of a minute. No record was made as to change of temperature, but the difference at the top and bottom of the shaft was possibly 25 degrees Fahrenheit. No special care was taken to test the instrument; I merely wish to place on record the results which were noted, going to show that the Hicks aneroid barometer is one of the most perfect which has ever been placed within the reach of the engineer.

WATER-WAY OF BRIDGES.

REGULAR MEETING, JAN. 17TH, 1880.—Mr. Thos. M. Cleemann read the following:

Mr. Phinehas Ball, the city engineer of Worcester, in his report, dated January 30th, 1869, gives the water-way of several bridges in that city, which had withstood all previous floods, as follows:

Nashua railroad bridge at Bridge street, area,	78·04	sq. feet.
" " " Exchange "	66·15	"
Union street " near " "	65·66	"
Central " "	112·16	"
Thomas " "	73·94	"
Lincoln Square "	48·24	"
Nashua Depot "	89·96	"
Arch at Grove Mill,	112·01	"

Under date of December 26th, 1879, he writes: "The area of the drainage basin above the several bridges referred to was, or is, 5024 acres; in this basin is one large pond called North Pond, having an area of 225 acres; the drainage area of this pond is 2097 acres. The bridges are now all removed, and have been for several years, by the building of what is known as the Mill Brook main sewer, so no observations have been taken at them, nor could be. The grade of this main sewer for most of its length is one foot in one thousand. The formula used is that of Mr. Bazalgette." This formula will give the diameter of the sewer 10 feet, or an area of 75½ square feet; Mr. Myers' formula would give an area of 71 square feet. It seems probable that the actual area of 48·24 square feet, which formerly existed at Lincoln Square, proved sufficient because of the equalizing of the flow of the flood water produced by the North Pond mentioned by Mr. Ball.

MINUTES OF MEETINGS.

Of the Club.

December 6th, 1879.—A business meeting was held, and, in the absence of the presiding officers, Mr. Darrach was called to the chair. Eight members were present. Messrs. Madeira and Colman were appointed tellers for the election of new members, and F. T. Freeland, H. M. Chance and J. J. de Kinder were declared by them to be elected. A very general discussion ensued on the subject of annual dues and initiation fees. The amendments proposed at the last business meeting[1] were voted upon, and it was decided that the annual dues should be seven and one-half dollars, and the initiation fee should remain five dollars.

The amendment to Art. III, Sec. 1, of the By-Laws, inserting after the words "to whom," in the second line, the words "in the case of active members," was carried.

Messrs. Hering, Murphy and Madeira proposed to amend Art. VIII of the By-Laws by striking out, in the first line, the word "three" and inserting "four;" in the nineteenth line, to strike out the words "and Library;" after the seventh section to insert a new section, as follows: "The Committee on Library shall consist of two members of the Board and the President."

Messrs. Murphy, Hering, Sellers, Billin and Darrach proposed the following amendment to Art. IV, Sec. 2, of the Constitution: After the words "vote at elections" in sixth line, insert the sentence: "They shall be sub-divided into two classes, viz., Resident and Non-Resident." After this insert the clauses: "Resident members shall be those residing within fifty miles of Philadelphia. Non-Resident members shall be entitled to all club privileges, but shall be required to pay only one-half the dues payable by resident members."

Nominations were received for officers of the Club to serve during 1880.

December 20th, 1879.—A regular meeting was held, with Mr. Henry G. Morris in the chair and twenty-four members present.

Mr. Wilfred Lewis read a paper "On the Angular Pitch of Square-threaded Screws." Mr. Henry G. Morris exhibited and described a slate ink-well for drawing-ink. Mr. Chas. E. Billin read a letter from Mr. Pontzen, of Paris, corresponding member, on the subject of narrow gauge railroads and street railways. Prof. L. M. Haupt exhibited and described a new transit rod with self-plumbing attachment. Messrs. Baltz and Clime, introduced by Mr. Hering, exhibited and described a new form of turbine. Mr. Hering exhibited and described an auto-

[1] See p. 237.

matic trap-valve for pipes, invented by Mr. Gorman. Mr. Ashburner made some statements regarding the great accuracy of a Hicks' Aneroid Barometer, and some confirmatory remarks were made by Messrs. Young and Billin. Mr. Billin read extracts from a translation of Monsieur Gautier's very able paper on Dephosphorization of Iron according to the Thomas & Gilchrist process.

JANUARY 3d, 1880.—A regular meeting was held, and, in the absence of the presiding officers, Prof. L. M. Haupt was called to the chair. There were 23 members present. Prof. L. M. Haupt read a paper by Gen. H. Haupt, on the Manufacture of Water Gas from Coal and Petroleum. A few remarks were made on the Tay Bridge.

JANUARY 10th, 1880.—The Second Annual meeting of the Club was held at 8.35 P. M. In the absence of the President and Vice-President, Prof. L. M. Haupt was called to the chair. Twenty-seven members were present.

The Annual Reports of the Treasurer, Corresponding Secretary, Recording Secretary and Board of Directors were read and accepted.

The Committee on Iron and Steel, Mr. Billin, Chairman, and the Committee on Metric System of Weights and Measures, Mr. Ashburner, Chairman, reported progress.

Messrs. Sanders and Cleemann, tellers for the annual election of officers, reported the following gentlemen as being duly elected for the year 1880.

President, Frederic Graff.

Vice-President, Percival Roberts, Jr.

Recording Secretary, Wilfred Lewis.

Corresponding Secretary and Treasurer, Charles E. Billin.

Board of Directors—Rudolph Hering, Coleman Sellers, Jr., Howard Murphy, George Burnham, Jr.

The vote for the fifth Director was a tie between Messrs. John A. Wilson and Herman Hoopes; there was therefore no election.

The constitutional amendment[1] proposed at the last business meeting was lost by a vote of 41 ayes and 3 nays, a two-thirds vote (50) of the members being required to adopt.

A special business meeting was held the same evening, Prof. L. M. Haupt remaining in the chair.

Messrs. H. Sellers and Taylor were appointed tellers, and the following gentlemen were elected members: Honorary member—John C. Trautwine. Active members—F. L. Miller, Axel. S. Vogt, D. Townsend, P. F. Brendlinger, H. G. H. Tarr, H. See, C. A. Merriam, T. R. Williamson, H. A. Freeman, M. Trump, E. D'Invilliers.

[1] See page 290.

An amendment to the By-Laws, creating a standing Committee on Library,[1] proposed at the last business meeting, was adopted.

JANUARY 17th, 1880. — A regular meeting was held, Frederic Graff, President, in the chair: Nineteen members were present.

The failure of the Tay Bridge was discussed by Messrs. Murphy, Hering and P. Roberts. In the absence of facts reported by experts, the discussion was only of a general nature, Mr. Roberts believing that this failure was another proof of the unreliability of cast iron to safely withstand any strain except simple and direct crushing. Mr. Freeland read a paper on Linkages for X^m. Linkages in general were defined and classified according to their degree of freedom, and a method was expounded by which the successive powers of X could be obtained one from another. Mr. Cleemann made a few remarks on the water-way of bridges in Worcester, Mass. Mr. Billin gave an interesting description of the lowering and boxing of the Egyptian Obelisk at Cairo, intended for New York City, and exhibited several large photographs, showing the machinery and the various stages of the work, from its commencement until the obelisk was in position to be shipped.

OF THE BOARD OF DIRECTORS.

DECEMBER 20th, 1879.—A stated meeting was held and some routine business transacted.

JANUARY 3d, 1880.—A special meeting was held, and several bills were passed. Messrs. Sanders and Cleemann were appointed tellers to conduct the annual election.

JANUARY 10th, 1880.—A special meeting was held. The reports of the Treasurer and Secretaries were submitted to the Board. They were approved and ordered to be presented to the Club as the report of the Board for the year 1879.

JANUARY 17th, 1880.—A stated meeting was held. The vacancy in the Board, caused by the tie vote at the annual election, was filled, the Board electing John A. Wilson. The Standing Committees for the year were then appointed by the President, as follows:

On Finance: Coleman Sellers, Jr., Howard Murphy.

On Members: Percival Roberts, Jr., Coleman Sellers, Jr.

On Publication: Rudolph Hering, George Burnham, Jr.

On Library: John A. Wilson, Howard Murphy.

[1] See page 290.

CONTRIBUTIONS TO THE LIBRARY.

From the AMERICAN INSTITUTE of MINING ENGINEERS. MR. THOS. M. DROWN, Sec'y.
Howe—A Direct Process of Copper Smelting.
Transactions. Vol. XII. May, 1878 to Feb., 1879.
From CHAS. E. BILLIN, Member of the Club:
Report of Investigating Committee Pennsylvania Railroad. 1874.
The Penn Monthly: Jan. and Dec., 1877.
Argument of Franklin B. Gowen before Legislative Committee of Pennsylvania. July, 1875.
Argument of Franklin B. Gowen in case of Commonwealth vs. Thos. Munley. 1876.
Report of President and Managers P. and R. R. R. Co. 1876.
Report of Committee Am. Soc. of C. E's on Exhibit of American Engineering. Paris, 1878.
Walter Smith—Industrial Art Education (an address). 1875.
Haskell—Accelerating or Multicharge Gun.
Journal of the Franklin Institute: Vols. 103, 104. Jan., Dec., 1877.
Album—Ponts Métalliques et Fondations Pneumatique, Société des Constructions des Batignolles. Paris.
Schneider et Cie. Catalogue des Objets Exposes à Paris. 1878.
Schneider et Cie. Navigation Fluviale et Maritime.
" " Ouvrages d'Arts.
" " Metallurgie.
Septième Rapport de la Direction du Chemin de Fer du Gothard.
Gothardbahn—Uebersichtskarte.
Album des Fers Aciers et du Creusot.
From the INSTITUTE OF CIVIL ENGINEERS, MR. JAMES FORREST, Sec'y, London:
Bell—On La Corbière Lighthouse, Jersey.
Landeman—On Timber Piling.
Rapier—On the Woosung Railway.
Courtney—On Cushing's Reversible Level.
Redman—On The River Thames.
Annual Report of the Council. 1879.
From L'ADMINISTRATION DES PONTS ET CHAUSSEES, Paris:
Annales—Nov.
From the SWEDISH SOCIETY OF CIVIL ENGINEERS, Stockholm:
Proceedings: Part 6. 1879.
From MR. ERNEST PONTZEN, Paris, Corresponding Member of the Club:
Lavoinne et Pontzen—Les Chemins de Fer en Amerique. Vol. 1st. Construction (1 Vol. text, 2 Vols. plates).
M. R. von Pischof—Beiträge zur Beleuchtung der allgemeinen Verhältnisse der österreichischen Eisenbahnen. 1879.
Société Imp. Roy. Priv. du Chemin de Fer Impératrice Elisabeth—I, Données Statistiques. II, Description des Objets et Plans Envoyés à Paris. 1878.
Notice Sur quelques unes des Principales Mines de l'Etat Autrichien Memoire sur la Production, l'Industrie, et de Commerce des Bois de l'Autriche.
From the AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Vienna:
Zeitschrift and Wochenschrift.
From the ENGINEERS CLUB OF THE NORTHWEST, MR. L. F. MORRHOUSE, Sec'y:
Proceedings. 1878-1879. 1 Vol.
From the AMERICAN IRON AND STEEL ASSOCIATION, MR. JAMES M. SWANK, Sec'y.
The Causes of our National Prosperity (an address).
From the SOCIETY OF CIVIL ENGINEERS, Paris:
Proceedings: Sept. and Oct. 1879.
From the PORTUGUESE SOCIETY OF ENGINEERS, Lisbon:
Proceedings: Aug., Sept. and Oct. 1879.
From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Ayres:
Proceedings: December. 1879.
From MESSRS. JOHN WILEY & SONS, New York:
Kent—Strength of Wrought and of Chain Cables.
From CLAXTON, REMSEN & HAFFELFINGER, Publishers, Phila.:
Trautwine—Field Practice of Laying out Railroad Curves. 1880.
From HON. C. P. PATTERSON, Supt. U. S. Coast and Geodetic Survey:
Annual Reports: 1871-72-73-74.
From THOS. M. CLEEMANN, Member of the Club:
Cleemann—The Railroad Engineer's Practice.
From SIR W. E. LOGAN, F.R.S.
Geological Survey of Canada. 21 Vols. and Maps.

LIST OF MEMBERS.

Additions.

Honorary Member.

TRAUTWINE, JOHN C., 530 N. 6th street. Elected Jan. 10th, 1880.

Active Members.

MILLER, F. L., 717 E. Dauphin street. Elected Jan. 10th, 1880.
VOGT, AXEL S., P. R. R., Altoona, Pa. " " "
TOWNSEND, DAVID, Bush Hill Iron Works, 16th and Buttonwood Sts. Elected Jan. 10th, 1880.
BRENDLINGER, P. F., Box 81, Braddocks, Allegheny County, Pa. Elected Jan. 10th, 1880.
TARR, H. G. H., 28 Platt street, N. Y. " " "
SEE, HORACE, Sup't Cramp's shipyard, City. " " "
MERRIAM, C. A., 817 South 19th street. " " "
WILLIAMSON, T. RONEY, Exchange Building, 3d and Walnut streets. Elected Jan. 10th, 1880.
FREEMAN, HAROLD A., 422 Walnut street. " " "
TRUMP, MICHAEL, 804 N. 17th street. " " "
D'INVILLIERS, EDWARD, 907 Walnut street. " " "

ANNOUNCEMENTS.

Members are requested to send to the Corresponding Secretary any information, original or published, which they may have or know of in regard to the subjects of Narrow Gauge and Street Railways. Mr. Ernest Pontzen, Corresponding Member, is preparing a work on American Railway Practice, and is desirous of obtaining all possible information on these subjects.

Members are requested to insert, in parenthesis, the metric equivalents of all weights and measures used in papers read before the Club; also, to place a metric scale in juxtaposition to the ordinary scale upon all drawings illustrating papers.

Illustrations of papers presented for publication should be drawn in broad, sharp lines upon white and smooth paper, with dull black ink. The size should be at least twice greater than the print, figures and lettering to correspond. No brush-work or colors can be accepted. It will be advisable for members to consult the Committee on Publication on the requirements for satisfactory reduction and reproduction before making the drawings.

PROCEEDINGS

OF THE

NGINEERS' CLUB

OF

PHILADELPHIA.

ORGANIZED 1877.

VOL. II.

PHILADELPHIA:
PUBLISHED BY THE CLUB.
1881.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advance in its publications.

Press of GLOBE PRINTING HOUSE, 112 N. 12th St., Philadelphia.

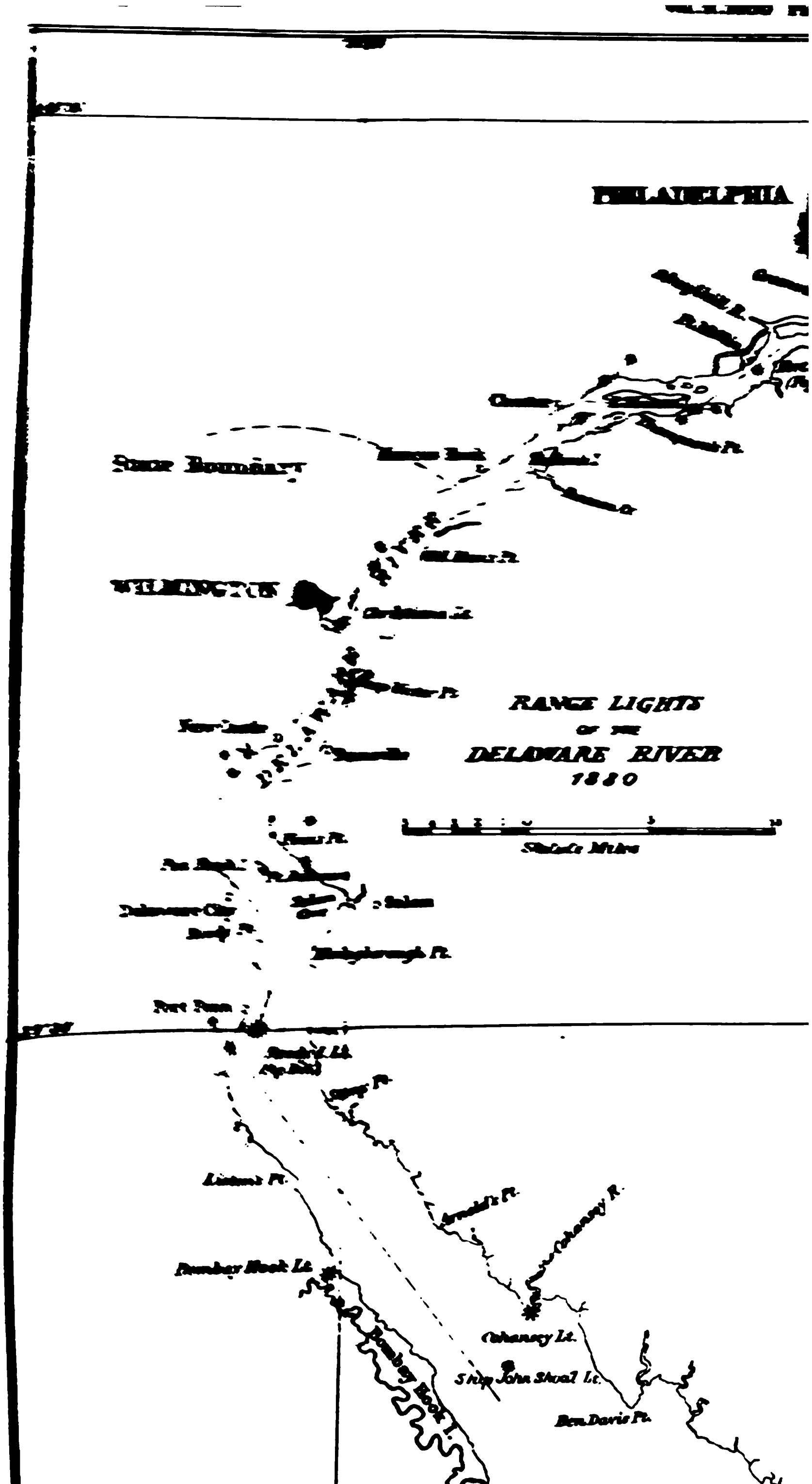
INDEX.

Note.—Notes and Communications published in this Volume by title only, are not indexed by *subjects*, but under name of *author* only.

ILLUSTRATIONS.

PLATES.

FIGURES.


PHILADELPHIA
State Boundary
RANGE LIGHTS
OF THE
DELAWARE RIVER
1880
Statute Miles
Salem
Liston's Pt.
Bombay Hook Lt.
Bombay Hook I.
Arnold's Pt.
Cohansey R.
Cohansey Lt.
Ship John Shoal Lt.
Ben Davis Pt.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

Vol. II.] SEPTEMBER, 1880. [No. 1.

I.

THE LIGHT-HOUSE SYSTEM OF THE DELAWARE RIVER, FROM THE HEAD OF THE BAY TO PHILADELPHIA.

By EDWARD PARRISH, Member of the Club.

Read February 7th, 1880.

As late as the year 1874, the only light-houses between Philadelphia and the capes of the Delaware of especial benefit to the navigation of the main ship channel, were located on the Brandywine Shoal, eight miles inside the mouth of the bay; on Reedy Island, some fifty miles further up, at the head of the bay and opposite Fort Mifflin on a pier in the river about forty miles above Reedy Island.

These three lights, together with a light-ship near the lower end of Cross Ledge Shoal, some eighteen miles above the Brandywine, and which was liable to be driven from its station by a floe of heavy ice, formed the only means, at night, save by the lead, of determining a channel one or two miles in width in an expanse varying from two to twenty-five miles wide.

In addition to the stations mentioned, there have been for a number of years, light-houses in existence at the mouths of the

principal creeks emptying into the Delaware, but being in most cases a long distance from the ship channel, were of but little consequence in marking it, and were chiefly intended for the benefit of the small craft trading or seeking a harbor in the creeks.

So that there was no alternative left for the master of a heavy draft vessel, arriving at the mouth of the Bay towards evening, but to anchor until the next morning, thus losing at least one day and considerable money. Upon steamers making regular trips this would entail serious loss.

The great growth of the commerce of this port has created a demand for all the aids to navigation that could be furnished, which has been met by the establishment of eighteen new light-stations and one steam fog syren on the Delaware, during the past six years, besides the placing and improvement of numerous new buoys and improved facilities for handling them; all of which have been primarily designed for marking the ship channel.

Without referring at this time to the two structures erected in the open bay, since 1874, between the Brandywine and Reedy Island lights, I propose to give you an account of the system adopted for lighting the somewhat tortuous channel of the river from the head of the Bay to Philadelphia. The method employed for the whole distance is that known as range or leading lights, and consists of the erection of two lights on a prolongation of the axis of the channel, and, in this instance, so arranged that the intersections of the successive range lines, so far as possible, shall occur in deep water, enabling vessels to pass from one line to the next with no unmarked space intervening.

In a long series of continuous ranges this is not always attainable, but in this case, with two slight exceptions, has been secured. By careful surveys of the channel, the best line is determined and prolonged on shore, or into shoal water, where the difficulties of construction would be the least, and on it are erected the necessary buildings for the exhibition of the lights, the front one having only sufficient height to be visible at the most distant point at which the range is to be used, whenever possible being shown from a lantern room connected with the keepers dwelling; the rear light having such an elevation as to appear over the front

from all points on the range at a minimum vertical angle of four minutes, to prevent the former from hiding the latter, with a horizontal distance between them, of about one-sixth the length of the range line, which element is, however, governed to some extent by the topographical features of the country and the circumstances of securing the site, any increase in this distance increasing the sensitiveness of the range but at the same time requiring a greater elevation for the rear light.

The lenticular part of the illuminating apparatus employed in range lights is designed to concentrate the light into a beam thrown in a single direction, that of the range, and differs from that employed to illuminate larger arcs of the horizon, in having the annular prisms arranged in vertical planes at right angles to the range line around a central lens.

Those in use thus far on the Delaware vary in diameter from twenty-four to twenty-nine inches; the latter on the longest range showing a brilliant light at a distance of fifteen miles.

In coming up the bay, the first group of ranges met with is designated as the "Listous Tree Range Lights," and consists of four lights marking two reaches of the channel.

The lower set of this group is located a short distance below the village of Port Penn, Delaware, and marks the last reach of the channel of the bay before entering the river. The front beacon of this set is a small frame house on the shore near the edge of the river, surmounted by a lantern room from which is exhibited the light, having an elevation of thirty feet above the water. The rear beacon is situated about one and three-quarter miles back from the front, and is a wrought iron tower, eight feet in diameter, enclosing a cast iron stairway and supported by a wrought iron frame-work, composed of six inclined posts, the bases of which rest in the angles of a hexagon, while the tops are attached to the shell of the tower immediately under the lantern. These posts are braced by a system of radial and lateral ties and struts, and the whole securely anchored to masonry.

The light in this tower has an elevation of 120 feet above the base, and 135 feet above the water.

This range is twelve miles in length, though the rear beacon

is visible several miles further down the bay, and serves as an excellent guide for coming on to the range.

The upper group of this set is located on Finn's Point, N. J., opposite Fort Delaware. The structures of it are similar to those just described, excepting that the rear beacon, being but a little over a mile from the front, is 100 feet in height.

This range intersects the former near the Dan Baker Shoal, and is used for about seven miles, until it is intersected again by the lower or New Castle range of the group known as the Bulkhead Shoal ranges, designed to guide vessels past a long shoal extending up the river from Pea Patch Island. It is used for a distance of four miles and is lighted from two frame structures located a short distance below Newcastle, Del. Both lights are exhibited from lantern rooms attached to the keepers dwellings, nature having supplied in this case a hill of sufficient height to avoid the necessity of building a high tower for the rear light.

The Newcastle range is intersected again by the upper range of this group, near the Bulkhead Shoal. This intersection takes place in about 18 feet of water, so that vessels of heavier draft must begin to turn before coming onto the upper range, the lights of which are situated on Deep Water Point, N. J., both on low ground and are exhibited from structures almost identical with those on Finn's Point.

The upper end of the Deep Water Point range is intersected by the Cherry Island Flat range, now nearly completed, for passing a prominent obstruction in the middle of the river, opposite the village of Pennsgrove, N. J. A portion of the channel marked by this range has a depth of but eighteen feet, and it is now being deepened to twenty-four feet by dredging.

At the upper end of the Cherry Island Flat range occurs the first break in the intersections of the successive range lines in deep water. The distance from this line to the next following is about three and one-half miles, and it is proposed to mark this short space by the insertion of a slide of red glass in the lantern of the light-house at the mouth of Christiana Creek, so arranged that the light shall change from white to red on approaching the shoal water at the side of the channel. This proposition has not been finally adopted, and other means may be used to accomplish

the object. The channel here, however, is wide and has bold outlines near the Delaware shore, so that however indicated, will leave but little to the judgement of the pilot to pass safely through it and strike the next range, located especially to pass through the Schooner Ledge, a dangerous ledge of rock between Chester and Marcus Hook, having on it about eighteen feet of water, through which, however, there is a narrow passage about 100 feet in width and twenty-four feet in depth. Through this gap the range line will pass and continue up to Chester, where it will be intersected by the range passing Tinicum Island.

The structures for the Schooner Ledge range will be, for the front beacon, a frame dwelling resting on iron columns, supported by wooden piles, surmounted by a lantern room showing the light at an elevation of thirty-five feet, and for the rear beacon a wrought iron tower 100 feet high, braced in the same way as those previously referred to, but being supplied with a larger watch room immediately below the lantern, and a vestibule at the base to serve as oil room and work rooms. This, as in all the towers, is located in close proximity to a dwelling for the keeper. The front beacon will be erected at the mouth of Crum Creek and the rear in the Darby Creek meadows, back of the Lazaretto, with a distance of about one and a half miles between them.

The Tinicum range, the next following the Schooner Ledge, leads from Chester to a point near Billings Port, N. J., and is followed by the Fort Mifflin range leading to the mouth of the Schuylkill River, through the dredged channel across the Fort Mifflin Bar.

The arrangement of the lights for these two ranges differs from any of the preceding, in that three structures are made to serve for both ranges, the intersection of the two lines being at the front beacon, while a small iron tower, 80 feet in height, will serve for the rear beacon of the Tinicum range, and a frame dwelling with tower attached, having a height of fifty feet, will serve for the rear beacon of the Fort Mifflin range.

Between these two ranges there is a short distance in the channel not directly marked by a range, but it is proposed to indicate the point at which vessels shall leave the Tinicum range by arranging on the rear tower of the Fort Mifflin range a red light,

which shall become visible at the proper point, and by a similar light on the rear beacon of the Tinicum range to mark the turning point on the Fort Mifflin range.

This system of lights extending through a distance of sixty miles, from the head of the bay to Philadelphia, will, when completed, enable a vessel to follow precisely the course of the best water without estimating distances or judging positions, leaving only to the judgement of the pilot the point at which to alter his course on one range, so as not to run beyond the next. And, moreover, vessels coming into port will have each group of lights ahead as they come up the river, until reaching the last range, which is but short.

Unless unforseen obstacles arise, the entire system will be completed during the present year, when the Delaware can lay claim to having the most extensive system of range lights in the United States, and probably to being the best lighted river in the world.

II.

ROCK DRILLS.

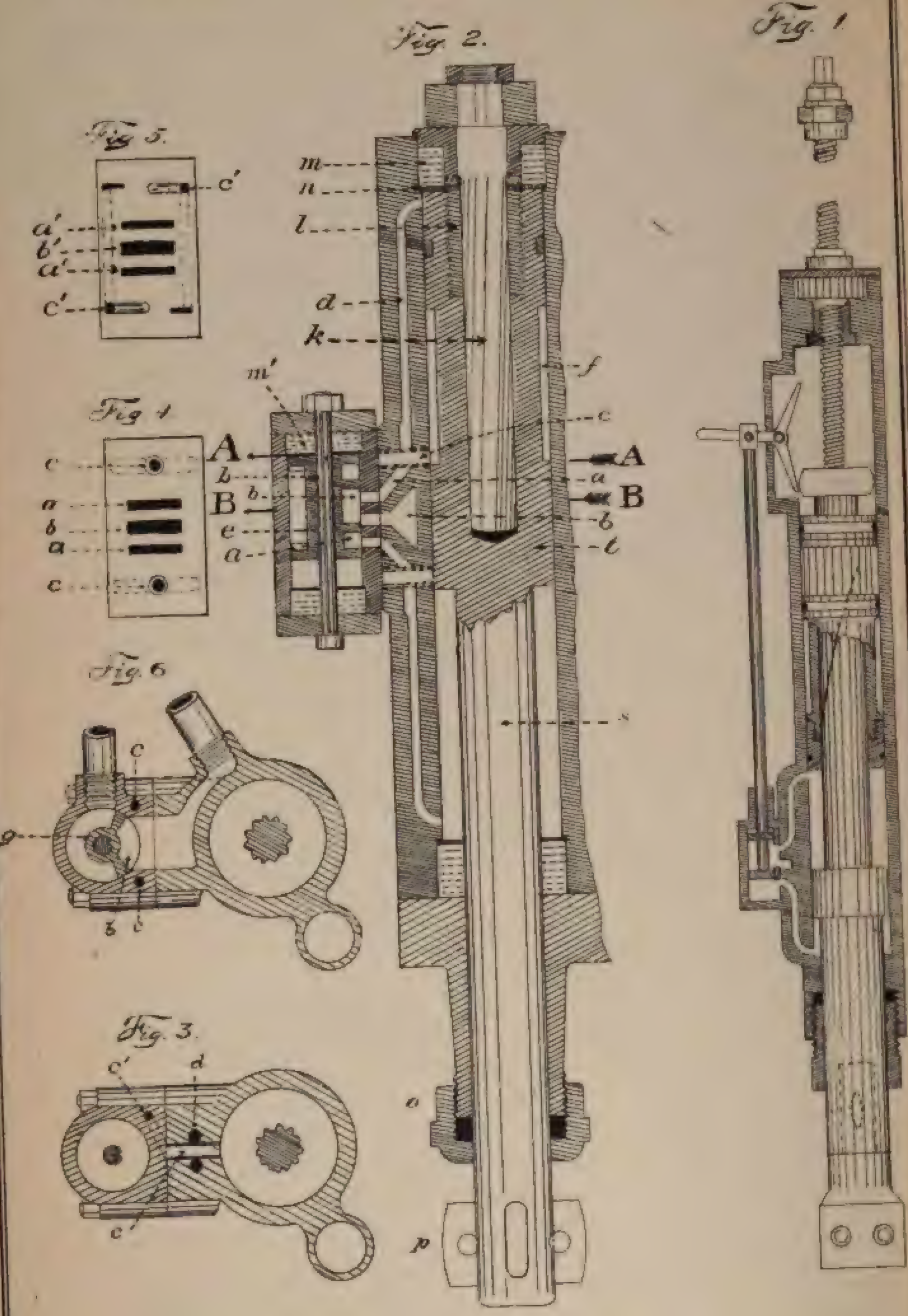
By Francis L. Miller, Member of the Club.

Read March 20th, 1880.

It will perhaps be interesting to mark the contrast existing between the first successful rock-drill and the latest.

It is generally conceded that the rock-drill introduced into the Hoosac Tunnel in 1866, was the first *successful* drilling machine which proved the *general* adaptability of drilling machines to mining purposes; although the drilling machine employed at Mt. Cenis Tunnel had, nine (9) years before, settled the question as to the *special* adaptability of rock boring machinery to a *specific* purpose. In short, the "Sommeiller Drilling Machine" successfully showed that the Mt. Cenis Tunnel could be drilled by machinery, whilst the drill introduced so successfully at Hoosac

Proc. Eng. Club. Phila. Vol. II. 1880 Plate II



in 1866, showed that blast holes could be drilled in *all kinds of mining work* by a small portable machine.

Prior to the advent of this American drill, many were the attempts to accomplish the same end, but all had failed, and it was reserved for an American to disclose the principles embodied in its construction.

The progress of Mt. Cenis Tunnel gave an impetus to engineering work of this character.

The projection of large engineering works involving mining operations, stimulated inventive talent to supersede the slow, tedious and costly process of hand drilling and blasting with gun powder.

At that time, 1866, the Mt. Cenis Tunnel, then chief of its class, was in the height of its progress. The average monthly advance of the heading had by the improved machines, been raised from one hundred (100) feet, to more than two hundred and twenty (220) feet.

There were but few tunnels in progress exceeding one mile in length, although many smaller ones were in course of construction.

A year before (1865) attempts were made to employ the terrific explosive nitro-glycerine in blasting. Dynamite was not known.

There was a considerable amount of mining being done in all parts of the world, yet in all these engineering works, excepting only the Mt. Cenis Tunnel, the drilling was done by hand, and gun powder was the only explosive.

This seems to have been the turning point, for from this year rapid progress was made not only in drilling machines, but in explosives, cartridges, fuses, etc.

At this time the Hoosac Tunnel was being driven by hand labor (drilling), although several commendable, but unsuccessful attempts had been made to introduce machine-drilling.

For twelve years had this enterprise dragged slowly and tediously along (at times the work ceasing entirely), with a prospect of occupying twelve years more.

Next to Mt. Cenis it was of greater magnitude than any tunnel previously attempted. More than five (5) miles long, with a cross sectional area of 450 sq. ft. (approximate), it is no wonder that the projectors became discouraged and dissatisfied with the slow

and clostly process of mining it by hand drilling and gun powder. Thousands of dollars had been expended in *ineffectual* attempts to *successfully* introduce a machine drill.

The want of such a machine which would more quickly and economically bore the blast holes, and of an explosive which would advance the face of the heading more than a couple of feet per shot, was seriously felt.

At length a machine drill was tried, which proved so successful, as to warrant its continuance from that time until the completion of the work.

It was much more effective than hand drilling, saving two-thirds the cost of drilling by hand.

We must not overlook the importance of the simple, yet effective means for compressing the air which was used as a motor for working the drill, the use of steam being so inconvenient as to be impracticable.

The machine was a great novelty, and many were the pilgrimages of engineers and others interested to witness its working. Imagine a machine, cylindrical in shape, three feet long, having a diameter of about four inches (outside).

It resembled in its construction a steam-engine cylinder, double acting, containing a piston whose rod extended through one head of the cylinder, which we shall call the lower cylinder head. To the end of this piston rod was a clamp for holding the drill rod. It was provided with a steam chest, and had induction ports and an exhaust port. A plain sliding valve moved in the steam chest, which by its movements back and forth, regulated the admission of compressed air into the cylinder, acting alternately upon the opposite sides of the piston, and imparting to it a reciprocating motion. The valve was not moved by an eccentric as in the steam engine, yet it was controlled by the movement of the piston in its forward and backward strokes. The piston-rod to which we have referred, was continued through the piston for a short distance, but not sufficiently to pass through the *upper* cylinder head. To this end of the piston-rod was fastened an annular ring, which on the forward and backward strokes came in contact with a lever or cam, which projected slightly inside

the cylinder. The movement of this cam was communicated to the valve, by means of a rod.

In this manner the reciprocating motion was imparted to the drill. There were two other motions, viz.: A rotary motion by which the drill bit was kept turning around on its axis constantly while the machine was running; also a motion by which the drill was moved forward and constantly kept up to its work, as the rock was cut away. These motions were accomplished by an ingenious device which can better be understood by reference to the accompanying drawing. This sectional elevation, Fig. 1, was enlarged from a cut contained in that excellent treatise on "Tunnelling and Rock-Drills," by our fellow-townsman, Henry S. Drinker.

In the drawing we see a section of a cyclinder with its heads strongly bolted down.

It contains a piston and rod formed of a *solid* piece of metal. It will be observed that the piston and rod are not connected with the valve, but are free at the moment the blow is struck. At the rear end of the piston rod is seen the annular ring, which operates the valve and feed device. We see the cam, which is really a lever projecting slightly inside the cylinder connected with the valve by the horizontal rod. The ratchet seen within the cylinder, has a rotary but not a reciprocating motion. It has also a feather projecting into the spiral groove, which latter is seen encircling the piston-rod. During the back stroke, the ratchet was prevented from rotating in one direction by a pall which dropped into the teeth of the ratchet. But during the forward stroke, the piston goes forward without rotating, thus compelling the ratchet to rotate under the pall. Thus a rotary motion is imparted to the drill rod, but the drill point is changed only during the forward stroke. The cylinder moved in a carriage or trough, and was guided in its motion forward by ways or grooves in the side of the trough.

The screw seen passing through the upper cylinder head, is not permanently attached to the cylinder, but passes up through the yoke, and is capable of a rotary but not a reciprocating motion.

The yoke is connected with the frame or carriage in which the cylinder slides. The screw was prevented from turning by the

use of check nuts. A nut was secured to the cylinder head in such a way as to rotate but not reciprocate. Around this nut a ratchet was placed which is engaged by a pall, said pall being connected with the end of a lever. This lever was so arranged that its forward end was struck by the annular cam when the piston advanced so far in the cylinder as to make the feed desirable. The lever on being struck by the annular ring, caused the pall to push the ratchet, and with it the nut around a small distance; the nut thus being turned, but prevented from moving forward, caused the cylinder to be advanced.

The drill bit was held fast by the chuck which is seen on the extremity of the piston-rod. Steam packing was used to prevent the compressed air from being admitted to the upper portion of the cylinder.

This machine struck about 300 blows per minute, and was operated by a pressure of 60 lbs. per sq. in. It did the work of several men, and was mounted upon a frame carriage, by which it was wheeled back out of range of the débris when the shot was fired.

The successful introduction of this drill revolutionized the method of mining.

Its simplicity and portability especially rendered it popular. Its convenience of adjustment enabled holes to be bored in every conceivable direction, and often where it would be impossible to bore them by hand drilling. Its lightness (weighing less than 300 lbs. for three inch cylinder) rendered it portable, so that it could quickly be removed from place to place.

It immediately found favor in all mining works where rock was encountered. In its motions it very nearly resembles the miner while drilling by hand. In hand drilling one man holds the drill while it is struck by one or more hammers. Between each blow he raises the drill, at the same time turning it around so as to change the position of the drill point, and then allows the drill to rest upon the rock while receiving the blow from the hammer. This in machine drilling is purposely avoided. It has been found that by the old method, the rock was pounded or mashed instead of being chipped off by steps, as in the case of machine drilling. By this a great saving in drill points is ob-

tained. Where a hand drill will require sharpening for every three inches bored, the steam drill will bore thirty inches and even more without re-sharpening. The drilling machine imitates the motions of a coal miner precisely. In this case the miner having a softer substance to bore through than rock, does not make use of hammers, but taking the drill in both hands, he forces it into the hole, imparting a reciprocating motion, at the same time rotating it and changing the drill point. It also has the motions of a jumper drill, so early used in connection with well boring and shaft sinking, but it has the further advantage of imparting more rapid blows, and of boring horizontally.

But excelling in effectiveness all previous drilling machines, it was nevertheless far from perfect. Weaknesses were continually being revealed, and these parts were from time to time supplanted by improvements. The exposed working parts were particularly objectionable, the cam and ratchets, and springs and palls were constantly failing, necessitating a large number of reserve drills, in fact there were required at least as many drills in reserve as there were working ones. One great improvement consisted in enclosing the cams and ratchets.

The principles of this drill were used as foundations for the construction of other drilling machines by other inventors, and it was not long before drill after drill came out in all parts of the world, each possessing some commendable feature, until now they are numbered by hundreds. Most of them were successful, many highly successful; at first rivalling, afterwards surpassing the first drill at Hoosac Tunnel in 1866.

In a book written by Richard Schram, "On the application of Machine Power in Rock Drilling," published a few years since, the author exhibits considerable erudition on the subject of rock-drills, and in an historical sketch of rock drilling machinery, he ranges the various rock drilling machines under five classes, as follows:

1st. The lever system, embracing Burleigh's, Schumann's, Sach's, McKean's, Warrington's, Ingersoll's, Dunn's, Roanhead's, Cranston's, Barrow's, and many other machines.

3d. The duplex system, embracing Sommeiller's and Ferroux's.

4th. The rotary system, embracing the Diamond Drill and Brandt's, etc.

5th. The direct acting system, including Darlington's, Schram's and Reynold's, without slide, and Osterkamp's, Schram's, Cederblom's and others, with slides.

It will be observed that the first successful drill at Hoosac Tunnel, is classed with the lever system, because of the levers or tappets employed to operate the valve and feed device.

The stimulating effect on railroad tunnelling, is best seen by the large number of tunnels constructed subsequently to the introduction of this drill.

Among the prominent ones were the long string of Pacific R. R. tunnels, commenced shortly after the introduction of this drill into Hoosac Tunnel.

Four years afterwards (1870) the Nesquehoning Tunnel was commenced, and two years after that (1872) the Sutro Tunnel Company began using machine drills, after having worked the Sutro Tunnel for three years previously with hand drills. About this time (1872) the Musconetcong and St. Gothard Tunnels were begun. The latter exceeding the Mt. Cenis Tunnel in magnitude, and the most stupendous work of the kind before or since attempted.

Many other railroad and mining tunnels were constructed; in fact the amount of work of this character that has been done since the advent of the first successful drilling machine at Hoosac Tunnel in 1866, and the introduction of dynamite a year or so later, is amazing, compared with that previously done in the same space of time.

The stimulating effect was felt not only in the railroad tunnels, but in all other kinds of mining work, where time was not of so much importance; as for instance, mining tunnels, sub-marine tunnels, and removal of harbor obstructions, besides open rock cuttings on line of railroads, and sewer trenches in rock.

These works have been prosecuted in all parts of the world, and machine drills of some kind have invariably been used.

There are places where the amount of drilling would not warrant the expense of steam or compressed air, and yet where a machine drill is desirable. To meet such a want, hand drilling

machines have been introduced, all being ingenious and more effective and economical than ordinary hand drilling.

Of the American drills of this type, the one originating with our neighbors at Phœnixville is quite popular. They all, however, contain good qualities, and are being gradually introduced in the work of limited quarries and in prospecting ore lands. For this latter purpose the Diamond Drill is unexcelled, but it is not a percussion drill, and does not come in this class.

The latest development of the percussion drill, is that invented in 1878.* It dispenses with the tappets and cams found so troublesome in the earlier drills.

The drawing will give a general idea of this drill as now manufactured.

Most practical drillmen prefer a hand feed to automatic feeding. It dispenses with troublesome devices for imparting the feed, and saves considerably in the weight of the machine itself. Besides a *laborer* of ordinary intelligence can in a short time, and without much exertion, administer as good a variable feed motion, and even better than is done by the automatic device. An attendant must be employed for a drill, even if automatic in its feed.

The machines are manufactured with the automatic feed, and also without it. In the latter, the feeding screw is provided with a crank, and passes through a yoke containing a fixed nut. It is continued through the axis of the cylinder, and within the cylinder it terminates in a fluted stem. The piston is provided with a correspondingly fluted cavity, so that a rotary motion is imparted to the drill while the machine is in operation.

The drawings represent a longitudinal section, Fig. 2. An underside view of the steam chest, Fig. 5. An elevation of that portion of the cylinder under the valve chest, with the valve chest removed, Fig. 4. Also two cross sections, showing the arrangement of the valve and ports. There are but two quickly moving parts, viz., the piston and the valve. The latter is not moved by any mechanical device, such as a lever or cam, but is changed or rather governed in its motions by the motion of the piston. The arrangement is very ingenious, and consists of two

* By Sergeant.

extra exhaust ports and passages, together with an exhaust chamber encircling the piston.

In all the drawings the same letters denote corresponding parts, which we will now describe. In the sectional elevation we see the cylinder and its piston (t) and piston-rod (s). The feeding screw having upon its lower end a fluted portion (k) for rotating the drill, and the automatically acting valve (g) with a rod (h) passing through its centre. The steam ports for the induction (a) and eduction (b) of air or steam to and from the cylinder. These corresponding ports in the steam chest are seen in Fig. 5. Steam passages to the cylinder are seen at (d). Rubber cushions in the cylinder (m) and valve cylinder (m^1) protected by a metal disk (n). At (l) is seen a fluted socket (e) screwed into the top part of the piston, and corresponds with the fluted stem (k) which passes through the socket. At (o) is seen the packing arrangement, and at (p) the clamp for holding the drill bar. The cylinder is provided with a seat for a steam chest at its centre.

In Fig. 4 we see the induction ports (a) to the main cylinder and exhaust port (b) to same, also the eduction ports to the valve cylinder (c). The steam chest, Fig. 5, is made to cover these ports. It contains two ports (c^1), which by passages formed in it, communicate with the ports of the large cylinder. The ports (c), Fig. 4, are covered by the ports (c^1) in Fig. 5. These two extra ports and passages serve as eduction ports for the small cylinder containing the piston valve, and which is formed in the steam chest.

The valve here employed is of peculiar construction, it being shown in section in Fig. 2 and Fig. 6 at (g). It will be seen that the valve is cylindrical in form, having projecting flanges at its ends, said flanges being enough smaller than the interior of the cylinder in which it moves to allow sufficient steam to pass them from the reduced portion at its centre, to move the valve from end to end of its cylinder, as the steam is exhausted from the ends thereof, as will be presently described. That portion of this valve which is in contact with the inner surface of the cylinder, or which is nearest to the main cylinder, has a projection formed upon its central portion, which is provided with a cavity (b), which in operation registers with the exhaust ports of the main

cylinder seen at (b, b'), Figs. 4, 5. The smaller ports on each side of the exhaust are induction ports (a, a'), Figs. 4, 5, and when the machine is in operation, register alternately with the induction ports to the main cylinder (a), Figs. 2, 4, 5.

In order that the valve may be made of such diameter as to allow the steam which operates it to pass from the reduced portion between the flanges (e), Fig. 2, to the ends of the valve cylinder, and still be retained in working contact with its cylinder; a rod or bolt is passed through its centre in the direction of its line of movement, upon which the valve slides, and by which it is to some extent guided. The bolt also serving to hold the heads of the valve cylinder in steam-tight.

To prevent this valve from being injured and from injuring the heads of the cylinder in which it moves, cushions of rubber are placed in each end of the cylinder and around the rod, as shown in Fig. 2, by which the movements of the valve are arrested at each terminus of its stroke, without any jarring or other injurious effect.

The main piston is formed of steel, the piston rod is attached to it and passes through the lower head of the cylinder, carrying at its extremity a clamp for holding the drill.

The drawing shows a piston of sufficient length to admit of there being formed at its centre a cavity of such a length, that when the piston has reached the terminus of its stroke in either direction, the cavity will still register with the ports leading from the steam chest, seen in Figs. 3, 4, 5 (c'), and thus allow the steam from the valve to be exhausted therein. The ends of the piston are provided with packing rings to prevent the passage of steam from the ends of the cylinder into the cavity in the centre of the piston.

The clamp (p) which holds the drill rod, has flanges or ears through which bolts are passed, for the purpose of causing it to clasp the drill shank, being further provided by a slit, by which this may be accomplished.

The action of the valve, piston and drill, will be as follows:

The parts being arranged for operation, steam or compressed air is admitted to the steam chest, through the opening in its side, and passes directly to the cavity formed between the two

flanges on the ends of the valve. If at this stage of the operation the valve is placed at one end of its cylinder, the steam will be exhausted at its opposite end, and the resistance to its movement in that direction being removed, the steam will rush past the flange nearest to the end of the cylinder, and force the valve in the opposite direction; its movement being controlled by the cavity in the main piston, which is of such a length as to prevent the valve from being shifted in the opposite direction, until the main piston has reached the end or nearly the end of its stroke, when it will uncover the exhaust port of the valve cylinder in which the steam is confined, and the steam contained therein will pass into one of the ports shown at (c^1), Fig. 5, thence to the opposite end of the chest, from which it will pass through the ports (c), Figs. 4, 2, to the cavity in the piston (f), Fig. 2. By this arrangement the valve is made to move automatically, and is controlled as to the time of its movement with reference to the main piston, by said piston, and without having any mechanical connection therewith. We thus see that there are but two quickly moving parts, and these are so arranged as to be subjected to the least possible wear.

Being composed principally of steel, and all its parts compactly arranged and simple in construction, these drills should last for years without repair. The rubber cushions being the most susceptible parts about them to wear, will have to be renewed from time to time, especially if steam is used.

The heaviest size manufactured does not exceed 600 lbs. in weight, while the smallest size, 2½ inch cylinder, weighs but 100 lbs., including tripod.

To give an idea of the particulars of the drill as manufactured, we will select the largest size cylinder, inside diameter 5 inches, length of stroke 6 inches to 7 inches, length of feed 2 feet 9 inches. Depth of hole the machine will bore, 40 feet. Diameter of hole it is capable of boring 3 to 6 inches. Average boring done in granite per 10 hours, 70 to 80 feet. Average length of boring in hard trap per 10 hours, 30 to 40 feet. Length of machine over all, 5 feet.

The largest size drill, 5 inch cylinder, is reckoned to do the work of from twelve to twenty-five men at hand drilling, and it

has been said to equal in effectiveness the labor of forty men, under particularly favorable conditions.

This drill as it is fed forward, moves in a trough or carriage, and for vertical drilling in the rock below or overhead, as in gadding or stoping, it is fastened to a tripod, whose legs are capable of adjustment to the inequalities of the surface of the rock, and which are weighted at the bottom to give stability while at work.

Seen at a distance boring into the rock below with the tripod legs extended, it resembles, for all the world, an over-grown mosquito with its proboscis in the earth, boring vigorously. It seems strange, at least a pity, that so useful a machine as the percussion rock drill should not have had a more romantic origin, as has been the case with so many useful machines. The most of us have calmly observed this denizen of the sea-shore, as he cooly poises himself upon our hand, and adjusts his proboscis to a convenient angle, and then with a rapid percussive motion penetrates the skin, yet none of us thought to take the hint and construct a rock drill upon this principle. It would at least have removed from the mosquito the imputation of having been created for no good purpose.

When used in a small tunnel as a drift or level, a steel column is firmly screwed against the roof and floor (within a few feet of the heading), by means of an adjusting screw with which it is provided, and the carriage containing the drill clamped to this column, enabling holes to be bored either along the roof or floor. Then before the blast the column and drill can be quickly and conveniently removed.

To facilitate the removal of the drill and column for a blast, the column is sometimes mounted upon a small carriage, which is easily wheeled out of the reach of the shot, and then by throwing to one side the débris, it may be pushed up to the face of the heading again.

For large tunnels a wooden frame carriage is employed, carrying a horizontal column, on which may be clamped several drills.

For sinking shafts and narrow trenches in rock, an iron or steel column is used, bearing against the sides of the excavation. To this the drilling machine is clamped.

These drills have been found to be very effective in boring

blast holes under water, as in the cases of removal of harbor obstructions, various expedients being resorted to for supporting the drill while working. In shallow water, a tripod with long legs capable of adjustment to the uneven rock surface is employed. In deep waters, temporary portable platforms are used to support the drill and workmen.

This drill representing the latest stage of the rock drill, it becomes interesting to conjecture what will be the characteristics of the next great drill, that will be destined to form another epoch in this branch of engineering.

St. Gothard, Mt. Cenis and Hoosac Tunnels will not always remain chief of their class. Works involving mining operations will undoubtedly be prosecuted, which, for stupendousness, will eclipse all that has yet been attempted. Among these may be mentioned the long talked of Channel Tunnel, designed to be twenty miles long, and the enormous cutting involved in the projected tide level canal at Panama, if that plan is carried out.

We have seen how the Hoosac Tunnel was, by a machine drill, completed in five years instead of twelve, as would otherwise have been required. Also that the latest drill is capable of trebling in effectiveness the drill at Hoosac; and the question arises, will this drill meet the requirements of the stupendous works of the future, or will a new and more powerful drill arise on another principle?

Shall we have an enormous drilling machine which shall persistently bore away with a rotary or a percussive motion, that shall be capable of steadily moving forward, day after day, excavating a clean cylindrical hole of the full diameter of the tunnel, thus enabling us to discard explosives and their attendant risks, particularly in the case of sub-marine excavations? Perhaps this is looking too far into the future, but no one will have the presumption to limit the possibilities of engineering works in view of the developments that have taken place during the last decade and a half.

III.

A MACHINE FOR THE SOLUTION OF THE EQUATION OF THE NTH DEGREE.

BY FRANK T. FREELAND, Member of the Club.

Read March 20th, 1880.

OF the continuous calculating machines devised by Sir William Thompson and Prof. James Thompson,* there is one for the solution of n linear equations between n unknown quantities and its construction suggests a machine for the rational integral equation of nth degree,

$$C_0x^n + C_1x^{n-1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad + C_{n-1}x + C_n = 0$$

The method to be used is obvious, and probably the reason it has not been previously employed, is that the linkages for the successive powers were undiscovered, with the exception of Prof. Sylvester's linkages for the square and cube and their combinations for the the 4th, 6th, . . . $\frac{2}{3}$rds . . . powers or in general $\pm\, 2^p3^q$ power, where p and q are real positive or negative integers. The formation of the linkages for any power has been explained in a paper read before the CLUB, January 17th, 1880, and published elsewhere.†

Let there be n straight levers L_1, L_2 . . . L_n so connected by linkages that a displacement x of L_1 at a unit's distance from the fulcrum produces a displacement x^2 of L_2 . . . and x^n of L_n.

On each lever as L_k let there be a pulley P_k whose axis may be adjusted parallel to and at a distance $\frac{1}{2}\, C_{n-k}$ from the axis of L_k.

Let a flexible inextensible cord have one end fastened to a fixed point F and passed around $P_1, P_2,$ . . . P_n in any order in which a positive displacement x would produce a maximum increase in the length of the cord contained in the system when C_0, . . . C_n are positive. Make the two portions of the cord as it leaves P_k parallel, perpendicular to L_k and on the same side of it, using fixed pulleys to change the direction of the cord if necessary. Let the cord after it leaves the system be furnished with a pointer, put

* Thompson and Tait, *Natural Philosophy.* New edition. Appendix B', Vol. I, Part I, p. 478.

† *American Journal of Mathematics*, Vol. III, No. 2.

under a slight tension and brought parallel to a scale whose units are the same as those of x.

If the lever L_1 is displaced a distance x, the pointer will move through a distance

$$+ C_0x^n + C_1x^{n-1} \quad . \quad . \quad . \quad . \quad . \quad . \quad + C_{n-2}x^2 + C_{n-1}x,$$

and if the pointer had been previously adjusted so as to read $+ C_n$ it would now indicate 0 whenever x passed through a real root of the equation or by a change of direction the real term of a pair of imaginary roots.

Description of a Machine for the Solution of the Quadratic Equation in its Simplest Form.

Let

$$x^2 + C_1x + C_2 = 0$$

be the given equation. The linkage used for the square is that of Prof. Sylvester.* In *Fig.* 1 let O be a fixed point, OB a link of a length a, C its middle point, CD a link of a length $\frac{1}{2}a$, OD a fixed line in which the point D moves. Let $\theta =$ the angle AOB.

Then

$$AD = a \text{ vers. } \theta \tag{1}$$

and

$$AB = 2a \sin. \tfrac{1}{2}\theta \tag{2}$$

Eliminating θ between (1) and (2)

$$(AB)^2 = 2a\, AD \tag{3}$$

and, if $a = \frac{1}{2}$. then

$$(AB)^2 = AD,$$

and the displacement of D is equal to the square of the displacement of B.

In this machine the unit of measurement for x is $\frac{1}{20}''$, and hence if AB and AD are given in 20th's of an inch

$$(20\ AB)^2 = 20\ 2a\ (20\ AD)$$

and if $20\ AB = k$ and $20\ AD = l$, then

$$k^2 = 40\ al$$

But a has been taken at $2\frac{1}{2}''$, hence

$$k^2 = 100\ l$$

and the displacement of D must be multiplied by 100 in order to be equal to the square of the displacement of B.

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* *American Journal of Mathematics*, Vol. I, No. 4, p. 386.

In *Fig.* 2 the general elevation of the machine, $OG = a = 2.5''$, $OC = \frac{a'}{2} = 15''$ or $a' = 30''$ and the motion is multiplied in the ratio of 30 : 2.5. The coefficient of x^2 is unity and $EF = \frac{1}{2}$ and is equal to $12\frac{1}{2}''$, hence unity will correspond to $25''$, and as $DE = 3''$ the motion is further multiplied in the ratio 25 : 3, or in all $\frac{30}{2.5}\frac{25}{3} = 100$ times. Therefore the displacement of DF, $25''$ from E will be the square of the displacement of G, both being measured in 20th's of an inch.

In *Fig.* 2 a standard U, rising from the base V, is shown. Pivoted to it at O is a bar JK with a projection CO. On U at E is pivoted a bar DEF. A link CD connects C and D. When JK is horizontal O, C and D are in a straight line and EF is horizontal, DE being perpendicular to DO. LM is a bar fixed to the standard. JK and LM are fitted with ways on which slide the blocks H and I shown in cross-section in *Fig.* 4. The block H carries a single pulley, and the block I, the reel Q and the pulleys R. A projection of the fixed bar LM at Z carries four pulleys and the bar DEF at F one. N is a vertical scale graduated into 20th's of an inch. T is a cord starting from the reel Q and then around in succession the pulleys H, R, Z, F, Y, and is stretched by a small weight P, sliding upon the scale N.

In *Fig.* 5 is shown a partial rear elevation. AB is a rod pivoted to the arm LM at A, $25''$ from S, sliding under an index at X, on the lever JK, and furnished with a scale graduated into one-half inches, thus giving the value of x directly, as $\frac{1}{2} : \frac{1}{20} :: 25 : 2.5$. When the bar JK is horizontal the index points to 0, or $x = 0$.

To show the operation of the machine suppose the equation to be solved to be

$$x^2 - 15x + 50 = 0$$

1st. Set the bar JK at 0.

2d. Set the blocks H and I opposite the number corresponding to the coefficient of x, in this case -15 (see *Fig.* 2).

3d. Turn the reel one way or the other until the pointer upon the cord near P comes opposite the absolute term of the equation, in this case $+50$ (see *Fig.* 3.)

4th. Move the bar JK one way or the other until the pointer upon the cord comes opposite the zero of the scale N.

5th. Read the scale at X and it will give one of the real roots of the equation.

In general there will be two positions of the bar which will bring the pointer to zero. In this case we find $x = +5$ or $+10$.

The model gives the real roots of quadratic equations when numerically less than 10 and when the coefficient of x is numerically less than 20, but a machine with a greater range could be readily constructed.

In this instance, imaginary roots can also be easily obtained. If $y =$ the distance of the pointer from the zero of the scale Z, then

$$y = x^2 + C_1 x + C_2$$

the equation of a parabola with its axis vertical. Putting $y = 0$

$$x = -\frac{C_1}{2} \pm \sqrt{\left\{-\left(C_2 - \frac{C_1^2}{4}\right)\right\}}$$

When $C_2 > \frac{C_1^2}{4}$ the pointer cannot be made to come to zero.

Putting

$$\frac{dy}{dx} = 2x + C_1 = 0$$

the coördinates of the point in the curve nearest the axis of x are

$$x = -\frac{C_1}{2} \text{ and } y = \frac{C_1^2}{4} - \frac{C_1^2}{2} + C_2 = C_2 - \frac{C_1^2}{4}$$

or, the distance of the pointer from zero when nearest to it gives the quantity under the radical and after the negative sign in the pair of imaginary roots.

APPENDIX.

NOTE I.—*Historical Sketch of the Problem.* Clairaut* (1713–65) effected the mechanical solution of the equation of the nth degree in a simple and ingenious manner by the use of rods not forming a linkage.

The theory of the machine may be briefly given as follows:—Let

$$a + bx + cx^2 + dx^3 + etc. = 0$$

be the given equation. Take two straight lines ZZ and SS inter-

* Borgnis, *Traité complet de mecanique*, t. *Des machines imitatives*, p. 226. Paris, 1820.

secting at right angles at O (*Fig.* 6). Let OZ be the axis of x. Draw MM parallel to SS and intersecting OZ at V, and let $OV = x$. Draw RR parallel to SS and at a distance unity. Lay off OA, AB, BC and CD proportional to a, b, c and d, the coefficients of the powers of x. Draw DE parallel to OZ. Draw CE and call Q the point of intersection with MM. Draw KF parallel to OZ through the point Q, and repeat the operation until the last point of intersection T is obtained.

Now $OA = a$, $AB = b$, $BC = c$, $CD = d$ and $OV = DM = x$, $DE = 1$, $ME = 1 - x$. By the similar triangles DEC and MEQ, $MQ = DK = d\,(1 - x)$.

$KB = BC + CD - DK = c + d - d(1 - x) = c + dx$.

By the similar triangles KFB and QFP,

$$PQ = KL = (c + dx)\,(1 - x).$$

But $AL = AD - DK - KL =$

$b + c + d - d\,(1 - x) - (c + dx)\,(1 - x) = b + cx + dx^2$.

Finally the similar triangles LGA and PGT give

$$PT = (b + cx + dx^2)\,(1 - x).$$

But $VT = VM - MQ - QP - PT =$

$$a + b + c + d - d\,(1 - x) - (c + dx)\,(1 - x)$$
$$- (b + cx + dx^2)\,(1 - x) = a + bx + cx^2 + dx^3.$$

Therefore when $VT = 0$, or when the point T coincides with V, the distance OV measured by same scale used in laying off $OA = a$, will give one of the roots of the equation.

The analytical engine invented by Charles Babbage,* in 1834, was designed to calculate the series of results obtained by substituting successive numerical values in an algebraic expression, and was to be provided with means for indicating critical points in the series.

If the expression were

$$y = f\,(x) = C_0 x^n + C_1 x^{n-1} \quad . \quad . \quad . \quad + C_{n-1}\, x + C_n$$

then the machine would calculate y for successive numerical values of x, and would cause a bell to strike and stop itself if y, while numerically decreasing, changed sign. The attendant would then know that y had passed through zero and that a root

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* Babbage, *Passages from the Life of a Philosopher*, p. 112. London, 1864.

See also Menebra, *Sketch of the Analytical Engine invented by Charles Babbage, Esq.* (In *Scientific Memoirs*, edited by Richard Taylor, Vol. III, p. 666. London, 1843.)

of the equation must lie between the last value of x and the preceding one.

DeRoos* made known, in 1879, a method for the solution of the equations of the second and third degree by linkages alone, and states that he believes it is possible to construct analogous combinations for the higher powers.

If the attempt is made it will be found to be impossible with the present knowledge, and that there is need of a linkage which will enable us to transport a dimension parallel to itself without conditions, and also a linkage for the product of two quantities.

NOTE II.—*The Transporter.* A linkage for transporting a dimension parallel to itself without conditions, may be formed by taking two bisectors and joining their bisecting points.

In *Fig.* 7 let ACE and BCD be the bisectors joined at C, and let AB be the given distance, then DE is equal and parallel to AB, for $BC = CD$, $AC = CE$ and $< ABC = < DCE$.

The revolution of a variable dimension through a variable angle can be accomplished by Prof. Cayley's octagon.†

NOTE III.—*Linkage for the Product.*

Let k and l be the two given quantities. Form $(k + l)$ and $(k - l)$ and then their squares $(k + l)^2$ and $(k - l)^2$. Subtract the second square from the first and $\frac{1}{4}$ of the difference will be the required product, for

$$\tfrac{1}{4}\left[(k + l)^2 - (k - l)^2\right] = kl$$

The combination will consist of 3 bisectors and 2 linkages for the square, of 5 cells each, together 13 cells or 78 links.

NOTE IV.—*Extension of the Method of DeRoos to the Solution of the Equation of the Fourth and Higher Degrees.*

Let

$$C_0x^4 + C_1x^3 + C_2x^2 + C_3x + C_4 = 0$$

be the given equation. By the theory of equations, when $C_0 = 1$ and a, b, c, and d are the roots of the equation,

$$-C_1 = a + b + c + d$$
$$C_2 = cd + ab + ac + bd + bc + ad$$

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* DeRoos, *Linkages, Van Nostrand's Engineering Magazine*, Vol. XXI, p. 246. New York, September, 1879.

Or, DeRoos, *Linkages*, p. 28, *Science Series*, No. 47. Van Nostrand, New York, 1879.

† *American Journal of Mathematics*, Vol. I, No. 4, p. 386.

$$-C_3 = abc + abd + acd + bcd$$
$$C_4 = abcd$$

Take four positive Peaucellier cells of a power *abcd*. Suppose the arms to be *abc*, *d*; *abd*, *c*; *acd*, *b*, and *bcd*, *a*. Articulate the cells in such a way that the distance between two of the points of the linkage will be

$$-C_3 = abc + abd + acd + bcd$$

Fix one of these points. By the use of three transports bring the dimensions a, b, c and d into successive positions on the line joining the two points measuring from the fixed point, thus giving

$$-C_1 = a + b + c + d$$

Take three negative Peaucellier cells of a power *abcd*, and suppose the arms to be *cd*, *ab*; *ac*, *bd*; *bc*, *ad*. Articulate the cells in such a way that the distance between two of the points of the linkage will be

$$C_2 = cd + ab + ac + bd + bc + ad$$

Express kinematically the conditions

$$a \times (b + c) = ab + ac$$
$$d \times (a + c) = ad + cd$$
$$b \times (c + d) = bd + bc$$

and $$a \times b \times c \times d = abcd = C_4.$$

which require in all, 6 product linkages and 5 transporters.

The compound linkage will then consist of 7 Peaucellier cells, 8 transporters and 6 product linkages; 101 cells or 606 links.

To solve the given equation it will only be necessary to make the distances $-C_1$, C_2, $-C_3$ and C_4 numerically equal to the corresponding coefficients of the equation, and then to measure off the numerical values of the roots from the distances a, b, c and d.

The method can be readily extended to equations of higher degrees.

These linkages will not give imaginary roots, and only the real roots of equations which have no imaginary roots.

Philada., February 23d, 1880.

IV.

THE MEXICO AND VERA CRUZ RAILROAD.

By Coleman Sellers, Jr., Member of the Club.

Read April 17th, 1880.

It is seldom that a railroad has such a combination of difficulties to contend with, as beset the early days of that which now runs from Vera Cruz to the city of Mexico. Not only did the climate and the natural difficulties of the route present almost insurmountable obstacles, but all sorts of adverse political and social influences had to be met and overcome. And the task was rendered no easier by the fact that stability of government has, as yet, been unattained in Mexico; and that throughout the history of the railway, its progress languished under a succession of governments, and its growth was in spite of revolutions and rebellions whose occurrence was quite a matter of course.

The need of a better mode of communication with the seaboard than that afforded by the slow mule team must have been early felt, and as far back as 1837, we read that a certain Don Francisco Arrillaga sought and obtained the exclusive privilege to construct an iron tramway from Mexico to Vera Cruz, with a branch to Puebla. The main line was expected to be 72½ leagues long, and to cost $5,000,000, while the branch to Puebla, about 45 kilometers long, was to cost $500,000. Nothing appears to have been done at this time, however, and the project next appeared in public in 1842, when Santa Anna, then President of the Republic, granted a new monopoly; but the seven years ending in 1849 found no more than one league of track completed. In 1855 Santa Anna transferred the privilege to the brothers Mosso. In 1857 Antonio Escandon bought the right to build a railroad from Vera Cruz to the Pacific; and he appears to have called to his aid a Colonel Talcott and other American engineers, several of whom fell victims to the climate of the *tierra caliente*. A revolution that same year put a stop to further progress.

In 1861 a new government renewed to Escandon his concession, but obliged him to undertake also a branch road to Puebla. In

1864, Escandon, who was prominent in fomenting the European invasion, (being one of those who invited Maximillian to the throne) transferred his concession to what was called the Imperial Mexican Co. Work now commenced with some sort of vigor; and the re-establishment of the Republic found fifty miles at the lower end, and eighty-eight at the upper end completed. Of course the first act of the restored government in 1867, was to deprive the company of its concession, because "it had contracted with a government which the French intervention had the pretention to establish in Mexico."

But in 1868 the concession was reconfirmed, and various American and English engineers, Buchanan, Foot, Murray, Hill, Pringle, Jackson and Braniff, together with a number of Mexicans were employed by the company or its contractors, and on the 1st of January, 1873, the road was formally opened by President Lerdo.

Thus, after thirty years of varied fortunes during which it passed under, or, as has been said, suffered under forty presidencies and one empire, the road was at last completed. What it cost the bondholders, most of whom were in England, I do not know, but up to the 30th of June, 1874, the Mexican government had paid out, it is said, $12,573,695. In 1879 the road was paying interest on its bonds; but, of course, had never declared a dividend, although this was in a measure due, perhaps, to the fact that the Government had neglected for many months to pay the concession for which it had pledged itself.

It may be said in passing that the Mexican government derives its revenues almost wholly from customs duties, on both imports and exports; and this is true not only of the Federal government, but also of States and municipalities, and goods destined for the remote interior are compelled to pay a succession of customs charges, as each petty state or town chooses to levy its toll. This is the *ordinary* method, and when its proceeds are insufficient to defray the expenses of the *de facto* government, a "forced loan" is exacted; and it now and then happens in their numerous civil wars, that a city will change hands two or three times in succession, and be compelled to contribute first to one and then to another of the struggling aspirants.

When the Federal government grants a subsidy or concession, it usually sets aside a portion of the revenues of some port of entry to meet the instalments as they become due. As the government rather readily grants these monopolies, it sometimes happens that the revenues are entirely unable to fulfil what is required of them, and hence the subsidies remain unpaid.

The railroad from Vera Cruz to Mexico is a single track road 260 miles long, and is undoubtedly a fine piece of engineering. It passes through the hot and nearly level coast country, climbs 4000 feet into the fertile intermediate valleys, then as many feet more to the top of the *Combres* in the second range of mountains; then gradually descends as it crosses the plateau and reaches the city of Mexico at about 7600 feet above sea level. The highest point on the road is about 8200 feet above the sea. The road ascends 6500 feet in sixty miles, and in one place climbs 2000 feet in fifteen miles. It is on these steep inclines that the most difficult engineering problems were met and overcome. There are no very long tunnels; but there are, I think, some seventeen or eighteen short ones, some of these are on the steep inclines, and in at least one case the tunnel is both inclined and curved with a reverse curve. This occurs on a gigantic horse-shoe bend, at the apex of which is an iron bridge on a heavy grade and curved to a radius of 352 feet. The road strikes one as being well and thoroughly built, and no expense was spared in its construction. All the bridges are of iron, were built in England, and are generally plate or lattice girder bridges on cast-iron columns supported by stone piers.

The road is being relaid with steel rails, and in February, 1879, all the iron had been replaced except that on the forty-seven miles nearest Vera Cruz.

The railroad at Vera Cruz terminates in a 700 feet iron pier or mole, which is said to have cost over $300,000. It is 15 feet wide, except at the outer end where for a distance of 180 feet it widens out to 60 feet; it is built of plate girders, supported on cast-iron screw piles, 15 feet apart in one direction and 30 feet in the other. The widened end carries four cranes of two tons capacity, and one capable of raising twenty tons. These cranes were made by Sir Wm. Armstrong and are operated by hydro-

static pressure. The accumulator which furnishes the power has a fourteen inch ram, which carries a plate iron tank holding about fifty tons of sand, and giving a working pressure of 700 lbs. per square inch. The harbor of Vera Cruz is little better than an open roadstead, and frequent "Northers" make it a dangerous berth for shipping. All loading and unloading must be done by lighters, clumsy sloops generally, and until the railroad mole was completed they all landed at an old stone pier, furnished with a few wooden davits in place of cranes, and terminating conveniently at its shore end in the custom house, *through* which, literally, exports and imports, emigrants and immigrants must alike pass. Now, although the railroad mole with its costly appliances has been in working order for some years, it has been of little service, because the enterprising association which monopolizes the lighterage business found the old arrangement more profitable, and hence forbade the use of the new plant. They have, however, at last relented enough to allow a partial use. I think machinery *im*ported in bulk and *ex*ports generally, if shipped over the railroad, the company is permitted to handle.

Of *rolling stock* the road has a variety; in about forty-five engines, twenty-one different styles and makers, English, American and Belgian are represented. Two Baldwin consolidation engines do duty on the lighter grades, but on the mountains, where a grade of four or four and one-half per cent. is often reached, they use the double ended "Fairlie" engines, with twelve 42″ driving wheels, and cylinders 15″×22″ or 16″×20″, or in some cases 46″ wheels and 16″×22″ cylinders.

The road officials claim great flexibility and tractive power for these engines, but admit that they have practically rebuilt them all during the few years they have been at work. They are run by a crew of four men, an engine driver, generally an American, (*who is paid about $7 a day, and is given a house and servant by the company*) a fireman, and two wood passers.

The cars used are of three classes, the second and third being of the American type, but plainly built and not upholstered. The first class carriages are all of the English style, seats upholstered and leather covered. Through trains are mixed passenger and freight, and each train terminates in a troop car in

which thirty Mexican infantry ride to guard (?) the train; and as the silver is always in a forward car it is necessary for robbers, generally speaking, to detach the troop car before they attempt to rob the train.

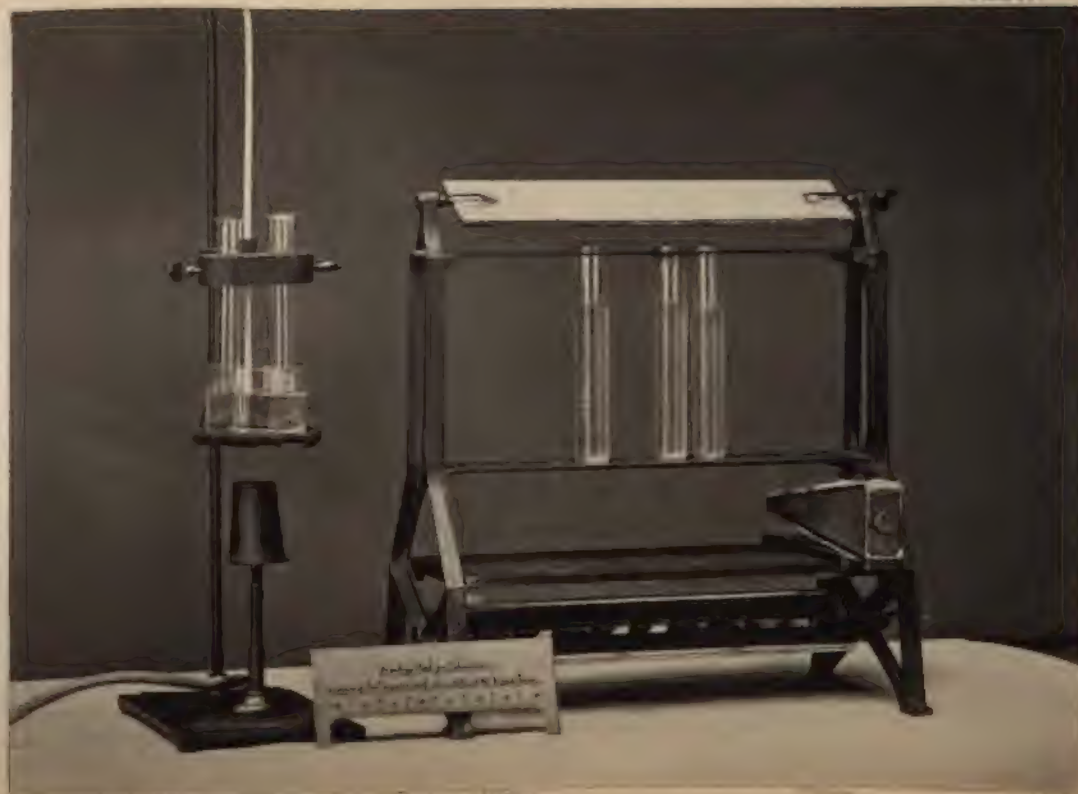
At each station one finds a body of horsemen belonging to the rural guard, a sort of mounted police in the pay of the department of the interior, well horsed, armed, paid and fed, and always ready to rob a stage coach or pronounce for any insurrectionist, who offers twenty-five cents a day above the government pay. There is no especial hurry about getting anywhere in Mexico, and the trains take about eighteen hours to make the 260 miles between the coast and the capitol. Montezuma's indian runners used to take 24 hours, I believe the story goes, and the old post riders often did it in twenty. But the cars travel fast enough and cheap enough to *just* prevent the competition of the old wagon trains, and one would think that at the ruling rates the business ought to pay. Thirty-two dollars for the round trip is first-class passenger fare; and freight is also divided into three classes, the last of which pays about $50 a ton for the 260 miles, and the first nearly twice as much. The considerate schedule permits the traveller to enjoy his meals deliberately, an hour or two being allowed for breakfast for instance, and does not hurry him away from the wondrous beauties of the ascent. When night sets in, however, and he begins to freeze after having sweltered all day, he will, I think, long for a Pulman car and sixty miles an hour.

Of course all the foreign importations of the most thickly settled part of the Republic pass over the Mexican railway, and as the city of Mexico alone boasts 200,000 inhabitants, many of them foreigners, it is evident that the road has a chance to do a large amount of through traffic.

Its local business as yet is small, the largest item being probably the transportation of pulque, the fermented juice of the Maguey, or Century Plant, the Mexican national beverage. Of this the road, it is said, carries enough to yield $1000 per day in freight charges.

Notwithstanding the fact, that the road was in process of construction for so many years, it is worthy of note that almost all

Plate IV



the work of building was actually done in about thirty months, viz.: from February, 1865 to June, 1866, and again, after the imperial fiasco, from September, 1871 to January, 1873.

When we consider the many difficulties of the undertaking, we realize the greatness of the achievement, and can not but admire the pluck, the energy, and the skill which brought it at last to a successful completion.

V.

A NEW METHOD FOR THE QUANTITATIVE DETERMINATION OF COMBINED CARBON IN CAST IRON AND STEEL.

By David Townsend, Member of the Club.

Read June 5th, 1880.

Of all the compounds of iron, none are to be compared in practical importance with those of carbon, and none possess greater interest from a scientific point of view. The influence of carbon in producing variations in the physical properties of iron is one of the most extraordinary phenomena in the whole range of metallurgy. Iron containing but a small quantity of carbon is called wrought iron and is soft, malleable, ductile and very tenacious; iron containing more carbon, between certain limits, gives all the varieties of steel from mere homogeneous metal to the hardest grades used for cutting tools; and lastly when iron contains above 2 per cent of carbon it becomes cast iron.

The carbon may be retained in the iron in one of two ways; either as graphite or in chemical combination with it (Fe_4C), and the manner of its retention forms an important point to be considered in the classification of the compounds of iron and carbon. Wrought iron rarely contains graphite; steel contains both, but the combined carbon always predominates, and cast iron may have either in excess according as it is grey, mottled or white.

Steel is always graded by the quantity of combined carbon it contains, the best authorities giving the following classification:

PER CENT.	USES.
1.58—1.38	Cannot be welded. Is malleable.
1.38—1.12	Malleable but difficult to weld.
1.12—0.88	Used principally for chisels, etc.
0.88—0.62	Cutting tools and files.
0.62—0.38	Mild steel for tires, etc.
0.38—0.15	Boiler plate, axles, etc.
0.15—0.05	Used for machinery, etc.

Seeing then that carbon is such an important element in iron, it is needless to say that the history of its determination is an interesting one. It began with Berzelius, but Karsten was the first to make any practical application of the different processes; doing wonderful work with a chloride of silver process which required from ten to twenty days for a single estimation.

In time, as the iron interests of the world were gradually developing, the demand for more accurate methods of analysis was supplied by the researches of the most eminent chemists, several excellent processes being invented, the best of which requires about four hours for its completion.

Following the remarkable inventions and patents of Bessemer by which any grade of steel could be made at pleasure, and in view of the fact that the classification of Bessemer steels depends upon the proportion of carbon they contain, it became an absolute necessity to determine with accuracy and rapidity the percentage of carbon in each heat.

Prof. Eggertz, of Fahlun, was the first (in 1862) to invent a process to accomplish this end, and it is to the credit of that distinguished metallurgist to say that his method still retains the greatest favor in the most important steel works of the world.

The process is based upon the fact that when iron or steel containing carbon in chemical combination is dissolved in nitric acid, a highly colored organic compound is formed and the solution assumes a brown tint which is dark in proportion to the percentage of carbon present. Iron and free carbon or graphite do not influence the color of the solution, as nitrate of iron is colorless and graphite is insoluble in nitric acid. This forms the basis of all the color nitric methods, of which I shall give a short description for the better understanding of our subject.

Eggertz's method is conducted as follows:—

0.1 gm. of iron or steel containing a known percentage of combined carbon is dissolved in 5 c. c. of pure nitric acid (1.2) at a temperature of 80° C. for about one hour, the resulting liquid being poured into a graduated burette and diluted to a normal solution.

Suppose the steel contains 0.75 per cent c. carb. and after solution we dilute the liquid to 7.5 c. c., then each c. c. will contain .0001 gm. of carbon. Now if we take the unknown steel and dissolve it as above described, then put it in an exactly similar burette, and dilute the solution until the two colors correspond; the percentage of carbon will be directly proportional to the amount of liquid. For instance, if the color of the second liquid corresponds to the first when the former stands at 45 c.c., by direct proportion the quantity of carbon is known to be 45 per cent. The chief difficulty is in preserving the normal solution a constant tint, as it becomes pale on keeping, especially if exposed to the light.

The Journal of the Franklin Institute for May, 1870, contains a communication from J. Blodget Button, of this city, giving several modifications of the Eggertz method. Instead of one standard solution, he uses several, varying by .02 per cent., from .0 per cent. up to .3 per cent. of carbon. The solutions are put in similar sized tubes, and arranged in a rack, with spaces between for the comparison of unknown steels. This method has several objections, the principal ones being, that a series of properly graded standard steels is hard to get, and also the difficulty of keeping a number of solutions constant at a standard tint.

Another process, which I shall just mention, was patented by Chas. M. Ryder, Aug. 30th, 1876. He claims that the magnetic limit of a steel is directly in proportion to the amount of combined carbon that it contains, and that when two magnetized pieces of steel are placed on a scale on opposite sides of a magnetic needle it will be in exact equilibrium when the same proportion is maintained between the squares of the distances on the scale as exists between the percentages of carbon in the steel. Never having tried the process I cannot pass upon its merits.

The process to which I would call your attention this evening

was suggested to me by Prof. Leeds while working in his laboratory.

It is based on the well known fact, announced by Eggertz, that iron or steel containing combined carbon when dissolved in pure nitric acid, gave a brown color which varied in depth directly in proportion to the amount of such carbon present. It differs, therefore, from the other processes before described only in the manner of comparing the colors.

The apparatus consists of a stand or rack arranged for holding ten comparison tubes, each of which when filled to the same depth hold 100 c. c. of liquid. Directly underneath these tubes is a platform on which slides a carriage holding a glass cell or wedge 10 inches long and 2 inches wide. This wedge contains the comparison liquid, properly standardized, and gives the different gradations of color according to the depth of the liquid. Under each tube, in the platform, is a rectangular slot allowing light which is reflected from the top mirror, to pass down through the colored liquid in the tubes and be received for comparison with the light transmitted through the wedge into the bottom mirror.

To conduct the operation 1 gram of steel containing a known amount of carbon (say 4 per cent.) is put in a tube and treated with 15 c. c. pure nitric acid having a sp. gr. of 1.2.

The tube is placed in a wooden clamp together with a thermometer and lowered into a dish of water kept constantly at 80° C. by means of a properly regulated gas jet.

In from 30 to 50 minutes the steel will be dissolved when any residue which may be left must be treated with 5 c. c. of fresh acid and then added to the main portion.

The liquid is now passed through a small asbestos filter, which has been previously purified, into one of the comparison tubes and after being diluted to 100 c. c. is placed in the rack. The wedge is now filled with a solution of caramel, diluted with water to the proper tint, and being placed upon the carriage the two colors are brought to exactly the same shade by moving the wedge in or out and making the comparison on the bottom mirror. This gives one point in a paper scale cut to the side of the wedge which represents 4 per cent. of carbon, then by pouring

out one-half the liquid and again filling up with water to the 100 c. c. mark, we obtain another point in the scale which is exactly one-half the preceding.

Thus in our case we obtain the points corresponding to .4, .2, .1, and .05, and by interpolation we obtain a scale running the whole length of the wedge.

For an unknown steel the process is obviously the same as described, with the exception that when the final comparison is made with the wedge and the scale applied, the percentage of carbon is read off at once. If the color should be too dark to come within the scale limits for 1 gram of material 5 grms. is taken and the reading multiplied by two (2); similarly should the color be too light 2 grms. are taken and the result divided by two (2).

Certain precautions have to be adopted to insure accuracy in the results.

The upper reflecting mirror should receive its light from some white surface or body having a uniform color otherwise it will transmit the inequalities of tint which it receives and thus cause error. The depth of solution in the comparison tubes should be exactly the same for similar quantities of liquid for the color will vary directly as its depth and not with special tint. The comparison liquid in the wedge remains normal for a long while if protected from the light when not in use, but it is safest to restandardize it at least once a month. What I claim especially for the process is the great accuracy and speed with which results may be obtained; also the simplicity of the apparatus by which any one not a chemist can make the comparisons without any difficulty.

VI.

THE FUTURE SEWERAGE REQUIREMENTS OF THE CITY OF PHILADELPHIA.

By Rudolph Hering, C.E., Member of the Club.

Read June 5th, 1880.

The Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia for the year 1876, contains the outlines of a system of intercepting sewers, designed "to relieve the city of its sewage without contaminating the water supply," and it very properly urged that "in order to rely upon the rivers as a source from whence to draw our water supply, their purity must be examined and their pollution prevented."

As Mr. Darrach has recently brought this system to the attention of the Club for discussion, I desire to state a few objections to some of its features, both with regard to its present and ultimate efficiency. Before doing so, however, it may be of interest to examine a few facts concerning the

Pollution of the Delaware and Schuylkill Rivers.

It is generally believed that our drinking water, which is obtained from both rivers, is, at times, not of a very wholesome quality. Chemical analyses have frequently been made of samples taken at different times and places which partially confirm this belief. The difficulty of selecting fair and average samples suggests an inquiry from a different direction, namely, ascertaining the actual amount of sewage conveyed to the rivers.

The absence of specific data and observations necessary for this purpose permits only of very rough approximations, but the results seem to be indicated sufficiently true for general conclusions.

It is still an undecided question as to whether river water used for drinking should be kept free from even an insignificant amount of sewage; whether there is a standard which denotes how much organic or other matter may reasonably be allowed in it; and to what extent and how soon river water purifies itself during its course.

Without going into the merits of the different opinions, which would lead very far, we will assume that water flowing within the limits of our city cannot purify itself, and that water which has been slightly polluted may yet not be objectionable, as in the case of our Schuylkill water, which was five years ago pronounced by experts* as being "about as good a water as we might wish to find for a large city," although it received sewage from many places within five miles of the pumping stations. Any germs of diseases entering and living in the river water cannot, of course, be destroyed by dilution: the probability of infection only is lessened. As these germs may be assumed to occur along with other organic matter, the amount of the latter can generally be considered as indicating the degree of pollution.

We have then to consider what maximum amount of sewage can be allowed in drinking water. Here, too, there is much disagreement, on account of the varied conditions, and we will again assume, for purposes of calculation, that the greatest amount permissible is 3 parts of organic refuse in 100,000 parts of water, by weight.

Human discharges have been estimated to average from 2 to 2.8 pounds per day, and the waste from all other sources, as kitchens, stables, streets, slaughter houses, etc., as having about the same weight per head of population. We will therefore estimate the total sewage to be 5 pounds per inhabitant per day.

The amount of sewage reaching the rivers may be ascertained in the following way: Upon the map of Philadelphia (Pl. No. 5), showing the drainage districts, we have plotted the density of population by marking a red spot for every election division, which represents about 1200 persons. By counting the spots in each drainage area its population may be approximated. Thus, we find that about 27,500 persons live on the area draining into the Fairmount pool. But the sewage of this entire population does not reach the river: it simply shows what can be expected in the future. Sewers now extend over only a portion of the districts, and all persons living on the line of a sewer do not yet

* Report on the Water Supply of Philadelphia by a Commission of Engineers, 1875.

drain into it. To find the approximate proportion, we are, in the absence of better information, aided by the following statistics:

The report of the Philadelphia Water Department gives the number of water-closets in the city as about 33,000. Not all of them discharge into sewers, and a number of houses have more than one, but it can be estimated that at least three-fourths of the number given in the report will represent the number of houses with water-closets discharging their entire sewage into sewers, which for the whole city is about 25,000 buildings. From records of the Board of Health, it is estimated that about 12,000 houses, having cesspools but no water-closets, are connected with sewers. It is further estimated that very nearly one-third of all sewer connections are for general waste water, excluding water-closets or cesspools; which, as we have seen, is equivalent to one-half the number discharging the entire sewage. There are also about 4,500 street inlets which, through gutters, receive the waste water of many houses not directly connected, and, finally, we have the streams, which are often little better than sewers themselves.

The total quantity of sewage daily carried to the rivers may, therefore, be estimated as coming from $25{,}000 + 12{,}000 + \frac{1}{2}\left[\frac{1}{2}(25{,}000 + 12{,}000)\right] +$ allowance for inlets and creeks = say 50,000 houses, or, as the average number of persons to one house is 5.8, from about 290,000 people.

In order to divide this amount over the Delaware and Schuylkill drainage areas, it will be near enough to consider the quantity of sewage to vary as the number of water-closets. Although this is not true for the wards alone, yet for the larger areas the errors will be almost eliminated. The Water Department Reports, giving the number of closets for every ward, enables this division to be made. Multiplying this number for each ward by a coefficient, which reduces it to the number of persons draining into the sewers, marking the products upon the population map, and proportionately dividing the wards which cover several districts, we can then estimate the proportion of sewage which is discharged into the Schuylkill, above and below the dam, and into the Delaware.

This coefficient being 290,000, divided by 33,000 = 8.8; the number of persons draining into the Fairmount pool is found to

be about 3,000; into the Schuylkill below the dam about 119,500; and into the Delaware about 167,500. The first amount, however, requires a very material correction. The proportion of water-closets draining into the river is less than in other sections of the river, but the refuse from the slaughter houses and the large number of mills situated along the river, at or near Manayunk, is much above the average allowance per head of population. From a report by Mr. J. E. Estabrook to the Park Commission, we may conclude that the daily discharge from these mills, in the shape of bleaching and dyeing waste, animal fat from woolwashings, the evacuations of the workmen engaged in the mills, etc., will equal the contaminations from at least 5,000 persons in addition to the 3,000 given before. We will therefore estimate the sewage from 8,000 persons as discharging into the river above the dam.

The minimum daily flow of the Schuylkill river is recorded as being less than 30,000,000 cubic feet, and lasting for over a month. Supposing one-half of all the sewage to be discharged in eight hours, the river during the same time delivering 10,000,000 cubic feet weighing 623,000,000 pounds, then if the sewage is uniformly distributed in the water, which is generally not even the case, it would require the refuse of less than 7,500 persons to pollute the water above the dam up to our assumed standard during the lowest stage of the water. We have just found that about 8,000 persons drain into it, showing that a pollution is probable.

No drinking water being drained from below the dam, the condition of the lower Schuylkill is not a serious question for many years to come.

The minimum daily flow of the Delaware at the head of tide is recorded as being 173,300,000 cubic feet, which would represent the amount of water daily pushing seaward in front of the city during a long drought. As it takes from twenty to thirty days for this quantity to pass through the distance which the river flows at one tide, and supposing that the daily discharge of sewage is sufficient to contaminate this daily addition of pure water, then we may assume that if the drought lasts about a month, the entire body of water passing the city will have become polluted. The fact that the sewage does not commingle

uniformly with the river water in the short distance of our city front, but remains in greater abundance near the shore, tends to make this time even shorter.

If the daily sewage is discharged into the Delaware evenly during twenty-four hours of a day, we find that a population of 65,000 would pollute its water to our standard in twenty or thirty days of drought. The entire population living on the Delaware slope is 553,000, but as we have seen, the sewage of only about 167,500 persons is conveyed into the river. Therefore, less than two-fifths of this number, neglecting the not inconsiderable refuse from the ships, would, if our premises are sufficiently accurate, cause the Delaware water to become unwholesome at certain times.

The general conclusions which we can now draw are: *First.* That after a protracted drought, both the Delaware water and the Fairmount pool may be injuriously polluted. *Secondly.* That the former may be more impure than the latter, which goes to confirm the chemical analysis of Booth and Garrett, who give a larger proportion of organic matter per gallon for the Delaware water. It consequently seems evident that an increased discharge of sewage into the latter, as long as it is pumped for drinking purposes in Philadelphia and Camden, should be looked upon as being at least as objectionable as an increase into Fairmount pool.

Discharging sewage into tidal rivers, whose water is used for drinking, is generally unsatisfactory, because the periods of slack-water—with us about fifteen minutes—permit much of the sewage to sink, and having reached a depth where the current is at all times weak, especially along the shore and in the docks, to deposit permanently or to be stirred up all at once during heavy tides or freshets.

By way of parenthesis, it may be interesting to note in connection with this subject, what a small percentage of our population has made use of the water carriage system. There are about 150,000 houses in the city and only 33,100 water-closets. The Board of Health estimates in all about 70,000 wells or cesspools, about 50,000 of which are not connected with the sewers. We may safely say, that in the improved sections of the city nearly 500,000 persons make no use of underground drainage, but store

up their fæces in privy wells, which are cleaned only when they are full, after saturating the surrounding earth with the liquid.

To form an idea of the magnitude of this pollution of the soil, let us consider that about 10,000 permits are yearly taken out for cleaning wells, which, averaging less than 200 cubic feet, gives a gross quantity of filth removed of less than 2,000,000 cubic feet. As one person discharges one cubic foot in twenty days, or at least eighteen cubic feet per year; 500,000 will discharge 9,000,000 cubic feet. Therefore, at least 7,000,000 cubic feet drain yearly into the soil beneath our habitations. This is neglecting the soakage of the cesspools having overflows into the sewers, and also the kitchen water which is frequently turned into them.

Intercepting Sewers.

The amount of sewage as thus estimated to discharge into the Fairmount pool and the Delaware river, although based upon data which closer study and observations will modify somewhat, nevertheless sufficiently confirms the fact that our drinking water will at no distant day, if not already, require protection from further pollution. This is most effectually accomplished by intercepting sewers, which collect and dispose of the sewage in a less injurious way.

The system proposed by Mr. Darrach has been advocated with this end in view. In discussing the same we should inquire into the requisites for a complete solution of the sewerage problem for our city. In doing so, I will give the outlines of another system, which appears to be better adapted to our future wants, and conclude with a comparison of the two.

A design for a system of sewerage for Philadelphia, which will not only answer for the present, but form an integral part of all the necessary extensions of the future, and demand no outlay of capital more than is required to meet the wants of the generation paying for it, is somewhat complicated by the facts, that the country is broken by the Schuylkill river and several large creeks; that many independent systems have already been built, and that the area is very extensive, being even larger than London.

The method pursued heretofore has been to treat each natural drainage area by itself, and allow the entire discharge to be at

or near the lowest point. The same policy has been followed in almost every city at some stage of its development, and is a perfectly natural and necessary one in order to discharge the storm waters. Were it not that the gradual increase of population, and therefore of sewerage eventually begins to seriously pollute the rivers, it would also be the only correct system to pursue.

As soon as the pollution becomes an evil, all sewage must then be intercepted before it reaches the river, and carried to some other locality, where it naturally is or can be made uninjurious, leaving the storm water alone to follow the old mains directly into the river. Where it becomes evident that a city will grow to such proportions, it is then a matter of economy to inquire into this ultimate disposition of its waste water; for slight modifications in alignment and grade of the ordinary or storm water sewers as they gradually become necessary, may enable them to be joined in with the final intercepting sewers at a small or no extra expense, whereas, if these are completely ignored, extensive reconstructions may be necessary.

We have seen that in the near future it will be imperative to construct a few intercepting sewers, and, as these should necessarily form branches of the entire system, it is clear that we have arrived at the time when the question for the final disposition of our sewage is not premature. If economy in our municipal management is an object to be sought, it will be necessary to build these first sections so that they will answer the ultimate requirements as well as the present.

In order to design a system which will effectually remove all the city's sewage, it is first necessary to consider: Where should the final outfall be located? Whether the sewage is turned into the Delaware during the first few hours of ebb-tide or utilized by irrigation or otherwise, does not matter at present; but one fact is certain, *i. e.*, the point of discharge must be so far distant from the city that the sewage will not return to its docks, or that the winds will not carry noxious odors from sewage reservoirs or farms back to its houses.

To answer this question we must inquire into the natural limits of growth of our city. The improvements of the southern portion are extending southward slowly but steadily. The Navy

Yard and the shipping interests along both rivers will gradually draw the city in that direction, especially when this section is made more healthy by proper grading and draining, and when the navigation facilities of the Delaware will have been perfected. The most rapid growth will be towards the higher grounds of the north and north-west, and will also extend, but more slowly, north-eastward along the Delaware. The centre of activity will be near Broad and Market streets: the business section extending towards the Delaware and the Schuylkill and southward, the dwellings spreading towards and over the elevated country running north-east of and parallel with the Delaware river, from Darby to Fox Chase.

A final disposition above the mouth of the Schuylkill, say at Greenwich Point, permits the sewage to pollute the river along the docks below, including the Navy Yard; a sewage farm or other mode of purification would become a nuisance, if not entirely impossible; a permanent reservoir would be more or less offensive, and, unless it is built large enough to hold at least an hour's sewage more than would be necessary at a point below the mouth of the Schuylkill, the sewage would flow up the latter river during every flood-tide nearly as far as Point Breeze. Until the lower section of the city is built up near the river, and the quantity of sewage is not too great, a temporary discharge, however, in this locality is economical and may be advisable. But an ultimate outfall for the Philadelphia sewage should be situated on the Delaware below the mouth of the Schuylkill, somewhere near Hog Island.

This site will be remote without being too distant from any part of the city likely to be built up; and by constructing a reservoir from which the sewage can be discharged only during the first two hours of ebb-tide, none could ever return to any part of the city. There is likewise ample room, should it be required, for irrigation or other modes of utilization that may be found expedient in the future. No other point seems to combine these advantages.

Granted, then, that this is the best locality for a final disposal of our sewage, the next question is: How can all the sewage be brought to it with the least delay of time and the least expense?

The latter can evidently be achieved only if gravity is resorted to as much as possible, and the amount requiring pumping is reduced to a minimum. The former is obtained by having a good grade and running the shortest available course.

In order that the greatest possible amount of sewage can reach the outfall by gravity, it must be collected by a high level intercepting sewer, beginning at the necessary elevation, to permit storage in the reservoir, running upwards at a grade sufficient to produce the required velocity, and branching off into all the valleys until it has traversed the entire city. Its general alignment would be about as indicated on the map.

The general route is quite direct, and excepting the short section through the built up part of the city, has but few bends. Nothing short of a detailed study, which, however, would not materially alter its course, can designate the particular streets upon which it could be most economically built.

This sewer receives all the drainage of West Philadelphia, excepting a narrow strip along the river, probably never requiring interception. It crosses the river Schuylkill just below Fairmount, runs into the city up to about Thirteenth and Spring Garden streets, and thence out to Frankford, etc., intercepting the area north-west of its line.

There are no difficulties in the way of this construction. The grades of a few streets would require adjustment, but as they are at present mostly unimproved, this could be easily accomplished if done soon enough. The Schuylkill can be crossed by means of a pipe bridge giving the same clear headway as the Fairmount bridge. Tacony creek could be crossed the same way at an elevation of about thirty feet above the water. Its fall is estimated at grades sufficient to give a velocity of from four to six feet per second, therefore discharging the sewage from Chestnut Hill and Frankford in less than five hours.

The branches from the main collector are as follows:

1. At Seventieth street a branch from Paschallville taking the sewage from the Cobb's creek drainage area.

2. At Fairmount a branch on the western bank of the Schuylkill, running towards the Zoological Gardens, intercepting the drainage of the Mantua creek sewer.

3. At Twenty-third and Spring Garden streets the drainage already intercepted from the eastern shore of the Schuylkill by the Pennsylvania avenue sewer.

4. Near Tenth and Diamond streets the Chestnut Hill branch, which as long as it remains in the Cohocksink drainage district can be identical with the flood water main sewer, and then with a heavy grade rising to near the top of the abrupt descent into the Wissahickon valley; it skirts the latter up to Chestnut Hill.

5. Near Second and Ontario streets the Wingohocking branch, extending northward to intercept the sewage brought down by the Wingohocking creek.

Thus all localities of the city from which the sewage can be removed by gravity are reached. The only exception is the high ground between the Wissahickon creek and the Schuylkill, which, if it ever requires relief, may be connected with the Chestnut Hill branch by means of a pipe bridge near the mouth of the creek.

The remaining sections of the city, situated below this high level sewer, ultimately require pumping. These are the territories draining into the Schuylkill from its eastern shore, below the dam and into the Delaware. To intercept them will require a sewer near the eastern bank of the Schuylkill, and another along the western shore of the Delaware. To reach the ultimate outfall they must unite somewhere near Girard Point, cross the Schuylkill by an inverted syphon similar to, though not so extensive, as the one now being built for the disposal of the Boston sewage across the bay, and then lead to Hog Island. The pumps should be on the eastern shore of the Schuylkill, the sewage flowing by gravity on the other side.

To find the most expedient elevation which will drain the greatest amount of sewage with the least pumping, it is necessary to know the heights at which all the sewage will be collectable. An examination of these shows that the elevation of — 15.0 or $6\frac{1}{2}$ feet below low water seems to be about the highest level to which it is practicable to bring the sewage at Girard Point. Assuming the surface of the reservoir to be + 5.0 and allowing five feet fall to it from the pumps, it requires a lift of not over thirty feet. Considering that the Boston sewage will be lifted thirty-five feet,

and the London sewage at Abbey Mills is pumped thirty-six feet, we are comparatively well situated.

Starting with this elevation at Girard Point and running up along the Schuylkill at a grade of 1:2000, we intercept all the sewage flowing into it with a very little readjusting of the lowest existing sewers. The only troublesome point is at Arch street, but here it will be much cheaper to reconstruct a large part of the sewer on this street than to lower the entire intercepting sewer and add to the permanent lift. At Fairmount the sewerage level can be as large as + 3.0, and at Manayunk, six miles above, increasing the grade to three feet per mile as low as + 21.0, which is three feet below the bottom of the canal.

Starting again at Girard Point with + 15.0, crossing over to Greenwich Point, thence up Front to Tasker, up Second to Poplar, etc., to Gunner's Run, as indicated, we can intercept all the sewage except from the Dock and Willow streets' sewers, both of which, however, can be readily adjusted. The grade is estimated at 1:2000 up to Snyder avenue, 1:1700 to Laurel street, and 1:1500 to Gunner's Run, etc.

The section from Snyder avenue to Gunner's Run intercepts nearly all the sewage polluting the Delaware. The districts not drained are the 16th, half the 17th, the 18th and 31st Wards (where water closets are comparatively scarce), and the Tacony creek basin.

The area, therefore, requiring an eventual lift of thirty feet covers all the low territory along the Schuylkill and the greater part of the populated portions along the Delaware.

Lastly, there is a district which is so low and distant from the outfall, that an additional lift must be resorted to. This area is situated north of Poplar street and between the sewer just described and the river, extending to Torresdale. The sewer relieving this territory must have its lowest point near Front and Laurel streets, where pumps could lift the sewage about fifteen feet into the Second street intercepting sewer.

The entire system is thus completed. Each natural valley or drainage area must have its own independent sewerage as built heretofore, to discharge the storm water as directly as possible into the rivers; but on its course each main is relieved of the

sewage proper from as many places as is consistent with the most economical way of final disposition, as we have seen, leaving the rain water alone by properly constructed overflows to continue its present course.

It now becomes necessary to examine into the order in which the various parts of this system will be required.

The section from Manayunk to Fairmount is evidently the first one needed, in order to maintain the purity of over four-fifths of our drinking water. It has been proposed for many years, and urged again by the Commission of Engineers, in their Report, 1875, who suggest that it may either be used as a sewer or as a conduit for pure water from Flatrock pool leading to the pumps at Belmont, Spring Garden and Fairmount. In either case it could eventually be joined in the above systems for ultimate disposal. This branch needs no pumping at present, as it discharges above mean high water. The cost of construction will not be more than $700,000.

The next section which will become necessary is the sewer from Gunner's Run to Snyder avenue, cutting off nearly all the sewage flowing into the Delaware. A simple gravity discharge is of no avail, because in order to collect the sewage it would be situated too low. Pumping with constant discharge below the city is also not sufficient, as the sewage would return with the flood tide to where it was collected. It will, therefore, be necessary to have a reservoir so that the sewage may be retained until the tide goes out. Evidently it cannot be economical at this time to construct the final outfall works. But until the lower part of the city is built up, a temporary reservoir and discharge below Snyder avenue seems to be the most economical solution of the problem. The offensiveness from a reservoir of about three acres in which sewage is replaced at every tide, and not left to decompose for days and weeks, as it does on the flats, will not be near as great as from the bone boiling establishments now located in that neighborhood. The expense of the reservoir would be comparatively slight, owing to the very suitable quality of the soil. The lift is about fourteen feet. The entire expense of construction, including reservoir and pumps, would not exceed $1,100,000.

These two sections probably suffice for the needs of the present

generation. When the condition of the Schuylkill below the dam becomes offensive, the entire West Philadelphia drainage might then be intercepted by the lower section of the high level collector and one compartment of the reservoir near Hog Island built, thus temporarily relieving the river of a large extent. When the Delaware again requires protection, the low level sewer starting at Laurel street would furnish relief, and then the extension of the high level collector beyond Fairmount, some branches of which may have been required and built before, and finally the completion of the low level sewers from Fairmount and Snyder avenue to Girard Point and the outfall.

At some previous time it may be found expedient to temporarily dispose of the sewage now draining into the Wissahickon creek and thence into the Schuylkill, by irrigation or other method, before it reaches the creek, until the population becomes too great, the high level collector having not yet been built.

In this way the total expense is divided over a long term of years, and each generation will be required to pay very little more than for its own immediate wants.

Having thus sketched a complete system, which appears to answer the present and all future demands, it remains to compare it with the one recommended by Mr. Darrach.

His "first district," which is West Philadelphia, is provided with a sewer running parallel to the Schuylkill and emptying into Darby creek. It is of less size than ours as it does not drain any territory east of the river. There is, however, a serious objection to discharging into Darby creek, as the sewage will not flow away rapidly in an irregular channel, but deposit in the eddies, along the banks, and otherwise be a nuisance to the country through which it flows. If the sewer is to discharge by gravity it would have to be higher, and therefore intercept less territory.

The "second district" comprises the eastern slope of the Schuylkill valley and the Delaware slope south of Norris street. The main feature is a sewer running diagonally across the city from the Falls to Broad and Norris street, and thence along Norris street to the river, as indicated by a black double line on the map. But ultimately it is to be carried down Second street to Greenwich Point, which is the outfall for the system. Another sewer inter-

cepts the Schuylkill shore below Fairmount and crosses over to the same outfall.

The diagonal sewer is intended to relieve the Fairmount pool, and is, as we have seen, the first one needed. An essential and important difference between the two systems therefore, is the location of this sewer, whether it should discharge at Fairmount below the dam or at Norris street into the Delaware.

The former is a mile shorter, with much less tunneling, as will be seen by comparing the profiles on the map. Yet would the latter offer sufficient advantages to compensate for this greater length and cost?

The fact that no water is pumped from the Schuylkill below the dam, but nearly one-fifth of our drinking water is obtained from the Delaware, seems strongly to negative the advantage of this line. The Delaware works are situated quite near the proposed outlet, the Camden pumps are opposite, and the Frankford works six miles above it. As the tide runs up over five hours during low water season, and at a velocity of over two miles an hour, there is already a strong probability of the works pumping polluted water during a drought, as we have seen. To increase this pollution by sewage, which could as well be turned into the Schuylkill, where it is not pumped, seems therefore not advisable.

It is suggested that this sewer may at the same time be used to convey away the storm water from the district through which it passes and thus save expense. This necessarily increases its size materially, which, together with the fact that nearly the entire length of the main sewer in that district has already been built, would not make it economical.

Another objection to the diagonal sewer lies in the fact that for two miles it runs under private property, unless a street could be laid out from Broad and Norris to the Falls.

When it becomes necessary to abandon the outfall at Greenwich Point and discharge the sewage below the mouth of the Schuylkill, then this diagonal sewer, which should form a part of an ultimate system, would cause the sewage from above the Falls to flow two miles further than if brought down along the eastern shore of the Schuylkill, consuming more time, and with a grade of, say only 1 : 2000, necessitating a permanent increase of pump-

age of five feet over the shorter route, or the interception of less territory.

The sewage from the Falls and Manayunk already reaches the lower Schuylkill, except what is pumped in the drinking water; the construction of the sewer can, therefore, not increase its pollution. On the other hand, keeping the refuse of about 8000 persons above the dam out of the river below it, which receives that of about 119,500 persons, could not be appreciated.

It seems, therefore, that both for the present and future the discharge of the Manayunk drainage into the Schuylkill below the dam, is preferable on grounds of efficiency as well as economy.

The sewer down Second street is substantially the same as on the map, but to carry the sewage from the diagonal sewer without additional pumping near Laurel street, would require it to be laid deeper.

The section on the eastern shore of the Schuylkill, in running across to Greenwich Point, allows the sewage to flow down the Delaware, and with return tide much of it will again enter and flow up the Schuylkill.

The "third district" of Mr. Darrach's system is substantially the same as the section above Laurel street and is similarly treated.

A disposal by gravity has not been proposed by him, and its necessity will indeed not appear for many years, as it intercepts at present only thinly populated districts. Only the upper Schuylkill sewage can now be removed without pumping. But it nevertheless is well to consider what gravity can eventually do in connection with a complete system, so that the proper authorities may reserve certain lands, adjust certain streets and lay others upon the city plan in good time, and build all ordinary sewers needed before, which have to cross the intercepting sewers, in a manner that will finally form effective and economical parts of the whole system.

THE RECEPTION OF MR. FERDINAND DE LESSEPS.

At the Business Meeting, held March 6th, 1880, after some discussion as to what part the Club should take in any reception that might be tendered to the distinguished visitor upon his arrival in Philadelphia, the Chair was moved to appoint a Committee with power to act with himself in making suitable arrangements. This Committee consisted of Messrs. A. R. Roberts, Madiera, Lehman, Ashburner and Murphy; President Frederic Graff, Chairman.

On Monday, March 8th, the Corresponding Secretary sent to M. de Lesseps, at Washington, D. C., the following telegram:

"The Engineers' Club of Philadelphia desire to extend to you their professional courtesy, and would respectfully ask you to name a time when an opportunity can be afforded them."

To this M. de Lesseps replied:

"I will arrive to-morrow, Tuesday, Philadelphia, six fifty, evening, but to leave at nine ten for San Francisco. If possible, I will be glad to pay a visit to your Club."

As the extreme shortness of this visit to our City rendered impossible any elaborate entertainment, it was decided that a delegation of the Club should receive him at the Pennsylvania R. R. Depot upon his arrival, and the General Agent, Mr. O. E. McClellan, Member of the Club, kindly placed his private offices at our disposal for that purpose.

Upon their arrival, the visitors were escorted from the train by President Frederic Graff, and the Rev. Professor Miel, President of the Reception Committee of French Citizens. When the party arrived at the rooms, they were met by the Committee and the following representatives of the Club: Messrs. H. M. Chance, O. B. Colton, Howard Constable, Wm. A. Cooper, W. C. Cranmer, Lewis M. Haupt, Wilfred Lewis, O. E. McClellan, Horace Sellers, Saml. L. Smedley, John W. Townsend and Geo. S. Webster.

Mr. Graff then made an address of welcome, assuring him, on behalf of the Club, of their desire to extend to him all the attention allowed by the extreme shortness of his visit, and of their high appreciation of the eminent reputation he had attained as an able, skillful and successful engineer.

In the reply of M. de Lesseps, he expressed great satisfaction at the result of his visits to New York and Washington, and his gratification at the disappearance of the many difficulties which had seemed to threaten the success of the inter-oceanic canal project. The members were then personally presented to him and to his very amiable lady, and a short time spent in conversation, when leave was taken and the distinguished visitors given in charge of the Committee of French Residents.

NOTES AND COMMUNICATIONS.

EARLY RAILROADING AND COAL TRADE.

MEETING, FEBRUARY 7th, 1880.—Mr. Howard Murphy read, on behalf of Mr. Israel W. Morris, the following extracts from "The History and Antiquities of the Town and County of the Town of New Castle upon Tyne," by John Brand, M.A. London, MDCCLXXXIX. Vol. II., which are remarkable in showing the wonderful similarity, in the ancient and modern methods of celebrating the completion of a railroad by a "free blow," and in the fate of some, at least, of those who embark in the enterprise of mining coal.

"WAGGONS AND WAGGON WAYS.

Mention occurs of "waggons and waines" as used at that time in the coal trade, in Grey's Chorographia, which was printed in the year 1649.

Waggons and waggon ways[a] have plainly been in use in the North, A. D. 1676. Lord Keeper Guildford, who was upon the northern circuit that year, thus describes them: "The manner of the carriage is by laying rails of timber from the colliery down to the river, exactly straight and parallel; and bulky carts are made with four rowlets, fitting these rails, whereby the carriage is so easy, that one horse will draw down four or five chaldron of coals, and is an immense benefit to the coal merchants."

The first waggons are said to have wanted the conveniencies of letting out at the bottom, having been emptied with shovels, like the present ballast waggons. It appears by the old books of the

Hostmen's Company, A. D. 1600, that the then coal waines contained eight bowls of coals, and some scarce seven bowls. The present waggons contain more than twice that quantity.

In the London Magazine for March, 1764, there is a representation and description of a coal waggon, communicated to the Editors by a Gentleman, who dates from Chester-le-street, 21st of December, 1763, and signs himself

T. S. POLYHISTOR.

* The first thing to be done in making a waggon way is to level the ground in such a manner as to take off all sudden ascents and descents; to effect which, it is sometimes necessary to cut through hills, and to raise an embankment, to carry the road through hollows. The road should be formed about twelve feet wide, and no part should have a greater descent than of one yard perpendicular in ten, of a horizontal line, nor a greater ascent than of one yard in thirty. After the road is formed, pieces of timber, about six feet long and six inches diameter, called sleepers, are laid across it, being eighteen or twenty-four inches distant from each other. Upon these sleepers other pieces of timber, called rails, of four or five inches square, are laid in a lateral direction four feet distant from each other, for the waggon wheels to run upon; which being firmly pinned to the sleepers, the road may then be filled with gravel and finished. The waggons, which are in the form of a common mill hopper, have four wheels, either made of solid wood or of cast iron. The body of the carriage is longer and wider at the top than at the bottom; the waggon usually has a kind of trap-door at the bottom, which, being loosed, permits the coals to run out without any trouble. The size of a waggon to carry fifty hundred weight of coals is as follows:

Length at the top, ...	7 feet, 9 inches.
Breadth at the top, ...	5 feet.
Length at the bottom, . . .	5 feet.
Breadth at the bottom, ...	2 feet, 6 inches.
Perpendicular height, . . .	4 feet, 3 inches.

Encyclopædia, ut supra.

The fillies or rims of the waggon wheels are hollow, so as to run upon springs of wood adapted thereto, with which the roads are laid.—"By this means, (says Hutchinson, View of Northumberland, Vol. II., p. 417) these carriages on an easy descent run without horses, and sometimes with that rapidity that a piece of wood, called a tiller, is obliged to be applied to one wheel, and pressed thereon by the weight of the attendant, who sits on it, to retard the motion; by the friction of which the tiller frequently, and sometimes the carriage, is set on fire."

This piece of wood, in the nature of a lever, is also called a convoy.

There is a tradition among the people belonging to the coal-works, that the first waggon that was used for this purpose in the vicinity of Newcastle, was lined with tin, and filled with the liquor called punch. It is easy to conjecture that the unlading of such a waggon would prove a very grateful task to the thirsty workmen.

Many of the superannuated workmen earn a little livelihood by what they call "creesing;" that is, crevicing, or cleaning out the crevices of the rails on these

waggon ways, upon which in steep places they are employed in laying cinders, to prevent their becoming too slippery, and the waggon from running amain.

When the axle of a loaded waggon breaks, it causes a great stop to the other waggons, and is called by the waggon-men "a caud (i. e. cold) pie."

Grey's account, in his Chorographia, of the coal trade of Newcastle, about A. D. 1649, is well worth transcribing:

"There come sometimes into this river for coales, three hundred sayles of ships." P. 19.

"Many thousand people are imployed in this trade of coales: many live by working of them in the pits: many live by conveying them in waggons and waines to the river Tine: many men are employed in conveying the coales in keeles from the stathes aboard the ships: one coal merchant imployeth five hundred or a thousand in his works of coals: yet, for all of his labour, care, and cost, can scarce live of his trade: nay, many of them hath consumed and spent great estates, and dyed beggars. I can remember one of many that raysed his estate by coale trade: many I remember that hath wasted great estates." P. 24, 25.

"Some South gentlemen have upon great hope of benefit come into this country to hazard their monies in coale-pits—Master Beaumont, a gentleman of great ingenuity and rare parts, adventured into our mines with his thirty thousand pounds; who brought with him many rare engines not known then in these parts; as the art to boore with iron rodds, to try the deepnesse and thicknesse of the coale; rare engines to draw water out of the pits; waggons with one horse to carry down coales from the pits to the stathes to the river, &c. Within few years he consumed all his money, and rode home upon his light horse."

"The coale trade began not past four-score years since: coales in former times was only used by smiths, and for burning of lime: woods in the south parts of England decaying, and the city of London, and other cities and townes growing populous, made the trade for coale increase yearely, and many great ships of burthen built, so that there was more coales vented in one yeare, then was in seven yeares, fo [illegible] yeares by past: This great trade hath made this towne to flourish in all trades." P. 26.

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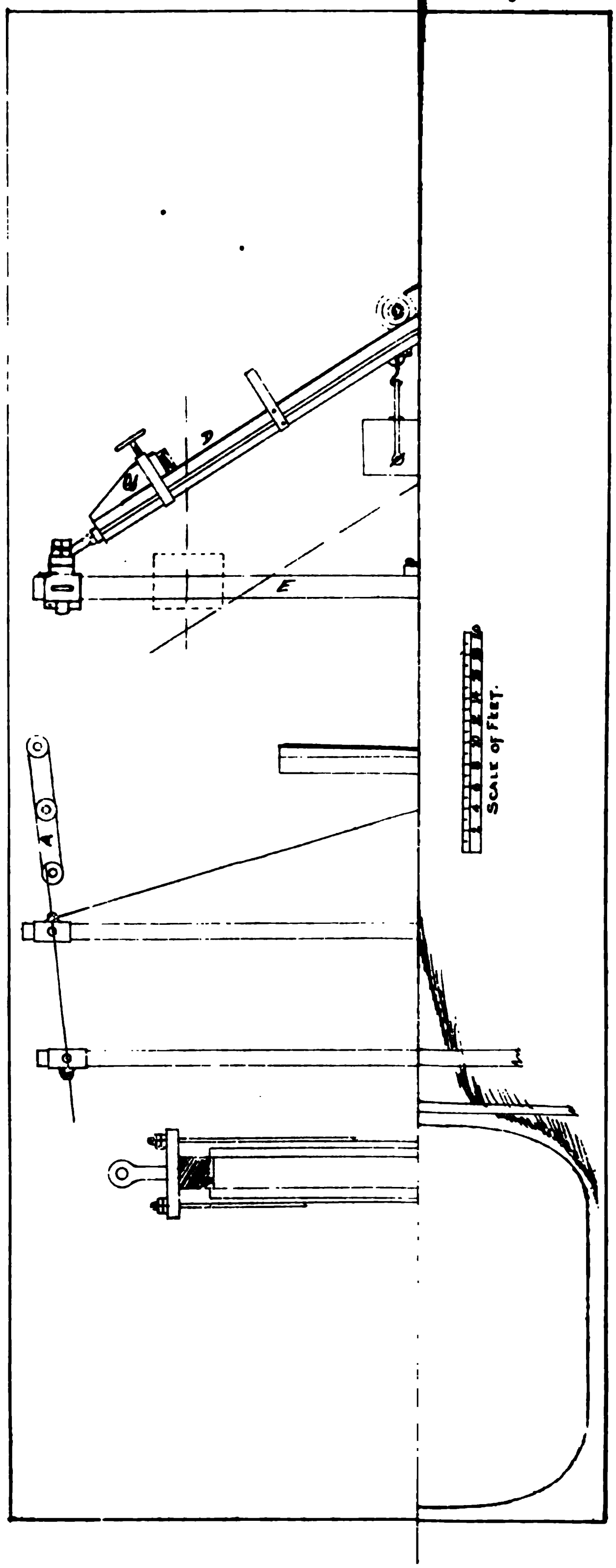
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SCALE OF FEET.

AN APPARATUS FOR HANDLING HEAVY CARGOES.

REGULAR MEETING, MARCH 20TH, 1880.—This paper was presented by Mr. J. J. de Kinder.

The ordinary method of discharging large sailing vessels is by hanging a heavy line (wire or hemp rope) over the hatch from which the cargo must be discharged; the line reaching from mast to mast, and from this line a block is suspended exactly over the centre of the hatch. Another block is suspended from the main yard arm, and, in order to land the cargo on a wharf, it is necessary to hoist the weight up nearly to the span; then a line, which has been fastened to the weight and runs through the yard arm block, is tightened and secured and the weight is lowered back again, the yard arm line causing it to describe an arc of a circle, of which the length of the yard arm line, from the block to the weight, is the radius.

This method requires a great deal of time, besides causing much delay on account of the tide. If the tide is low the radius named is generally too long to permit of the weight being suspended over the wharf; if the tide is high, it is generally necessary to gently lower on the yard arm tackle, as the weight will be suspended too high for working purposes. Often, the heavy wind blows the ship away some distance from the landing, despite well-secured moorings, and the yard arm, in that case, often proves too short to land the weight clear on the landing.

In some places steam swinging cranes are used, which are, in the first place, very expensive, and in the second, are difficult to swing around clear of the ropes, stages, etc., where rigging is close together.

The sketch shows a landing derrick with elevated railway which the author built for his own use at Girard Point; the railroad tracks, upon which the freight cars and ballast cars move, being one hundred feet away from the wharf;—a distance which no derrick could well swing and bridge over. It consists of two white pine masts, 80 feet long, 32 inches at the butt and 14 inches at the top. They are placed 5 feet 8 inches apart in the clear, and go down 40 feet under the wharf level and into the mud, and are well wedged in the crib work through which they pass. They also have strong iron bands round the top, from which run back and sideways wire guys which are $\frac{3}{4}$ inch diameter, each having a turnbuckle for tightening it.

Twenty-two feet above the wharf each mast carries a hinge, to which are hinged yellow pine pieces, 6 inches × 10 inches × 33 feet long, one hinge being 8 inches in advance of the other. The two pine pieces are coupled at their ends by an iron bar, *A*, 2 inches × 3½ inches; two 2-inch bolts going through the ends of the bars and through the ends of the sticks. They are lined with $\frac{3}{8}$-inch iron all around, 8 inches long.

Another iron stay or bar, *B*, connects the masts 20 feet above the hinges. From the centre of the bar *A* to the centre of the bar *B* a railway is suspended. It consists of two pieces white pine, 4 inches × 12 inches, about 30 feet long, which are kept 12 inches apart by means of a 12-inch block at each end. An iron plate, 2 inches × 4 inches, goes across each end, and two 1-inch iron rods go from plate to plate on either side of the 4 inch × 12 inch, and are screwed well up. The rods are kept in their places by means of staples, and two iron bands of horse-shoe form bolted on either, 4 inch × 12 inch, prevent the pieces from swagging in the middle, and an iron plate runs over the 4 inch part which forms the top of the 4 inch × 12 inch. The iron

plates at either end have a 2½-inch goose-neck rivetted on in the centre of the plates and these are bolted or hinged to the plates *A* and *B*. With this arrangement, there being but one hinge at top and bottom, the whole thing can be swung in at right angles to the mast, and for this reason one of the hinges on the mast which carry the horizontal pieces is placed 8 inches in advance of the other.

A travelling block runs over this inclined railway, which is the patent of W. Hunt, of New York. A bridge is hinged between the masts and is lowered onto and between the horizontal booms.

The railway is double track, without switch, and with two small dump cars, the capacity of each being one and one-half tons of coal, ore, or ballast.

A 4-inch manilla line is used for hoisting. While hoisting the tub from the hold to the heel of the traveling block, *C*, there is a double purchase on two parts of a line, and as soon as the foot block and traveling block meet, it becomes a single purchase, and, for the same speed of engine, double the speed for the weight is obtained. The inclined railway, *DD*, makes an angle of 33° with the horizontal boom, *EE*. This angle prevents the traveling block from coming in before the weight is home, and will cause the traveling block on its return trip to run down to each proper place (which is determined by a movable clamped block carrying rubber cushions,) before the empty tub lowers.

FF are ⅞-inch iron bars with turnbuckles and are provided with a hook on the lower end, and can thus be taken loose and removed from the horizontal booms when it becomes necessary to swing the apparatus inboard. They are applied and screwed home previous to commencing work, as they support the bridge and the loaded cars—in other words, they take the strain off the horizontal pieces *EE*.

I have built this apparatus to accommodate the largest sailing vessels afloat, under the most disadvantageous circumstances, and it will operate without any trouble when the ship is listed badly, when nearly empty, at a very high tide or a very low one; the length of the booms *EE* being sufficient to guarantee it to work for any beam, and the movable block *G* determining the position of the traveling block when stationary, in the act of hoisting or lowering.

I use a 9-inch × 10-inch cylinder hoist, built by Stokes & Parrish, of Philadelphia; the tubs hold fifteen hundredweight of ore or ballast. I let the exhaust steam back into an iron tank which holds the feed-water for the boiler; with only fifty pounds steam, burning three hundred and sixty pounds bituminous coal in ten hours, I can handle three hundred and sixty tons of ore or ballast, or one ton per pound of coal. As one hundred and sixty tons of cargo in the old method is considered a good day's work for a consumption of four hundred and eighty pounds of coal, I think this result is very satisfactory. The whole structure, outside of engine and boiler, can be built, including cars, railroad iron, etc., for $2000.

LAND SURVEYING IN PENNSYLVANIA.

Meeting, March 20th, 1880.—Mr. Chas. E. Billin made the following remarks in regard to improvements in existing methods in land surveying:

The subject is one which may not be considered as of direct and personal interest to each Member of the Club, but it certainly is a subject of sufficient importance to deserve our attention.

The Members of this Club are doubtless familiar with the Memorial, praying for a thorough geodetic survey of the State, which was prepared and presented to the Legislature of Pennsylvania, in January, 1879; it has since been published in Vol. I, No. 1, of our Proceedings.* The great necessity for such work was felt both by the Members of the Club and by the many learned societies and influential citizens who joined in petitioning for an appropriation from the Legislature in furtherance of the object sought, viz., good and reliable maps of each county and township in the State.

The originators of the movement had also in view the fact that such work as was proposed would bring out and emphasize many important points in connection with data, methods and results, used and obtained by country surveyors; and trusted that the publicity thus given to old and rude methods at present employed would lead to wise legislation with reference to land surveying, improvements in existing methods, the establishment of fixed and needed standards, and, as a consequence, to a higher standard among the men in our State, who perform the responsible work of surveying.

The Legislature of 1878–1879 failed to pass the acts necessary for the organization of such work, and Pennsylvania is therefore obliged to continue to submit to the disgrace of having no reliable map of its vast domains. The most valuable lands of the Commonwealth, as well as the poorest, are still surveyed and measured by methods which were already old and faulty when our forefathers used them. I can not help complaining of the very unwise policy which prompted our would-be statesmen in Harrisburg to pass by a measure so important to every property-holder and interest in the State.

The principal duties at present expected of a surveyor are in themselves very simple. They are that he shall be able to use the surveyor's chain and compass, to plot courses and calculate the areas within boundary lines. These duties are often discharged ignorantly and very carelessly. But even when intelligent, conscientious men attempt to do thorough surveying work, they are frequently met by what prove insurmountable difficulties. The tracing or following of boundary lines, which were located many years ago by very imperfect means, and which have often been either erroneously located or obliterated, is a most difficult task. But the old methods are still in use, and it is to their correction that the Club should devote some of its energies.

Beside the correction of existing methods in land surveying, the Club should also aim to advance and enlarge the scope of work among our surveyors. The office of Surveyor should be one of appointment, depending on examination by a technical Board; and no other surveyors than those authorized by the Board should be permitted to record work.

There is, in fact, a large amount of work which should be included in the duties of the Surveyor. He should know something of the art of correctly representing the details of the surface by topographical sketching. By the collection and compilation of topographical work, which can be easily done when running out boundary lines, not only much valuable material in regard to open and more settled portions of the State could be preserved, but such work, in many mountainous districts, which are to-day scarcely known, would be found most valuable in working out trustworthy county maps. The location of streams and other natural features would much en-

* Vol. I, page 70.

hance the value of the survey. In unimproved districts of the State this would help in the elucidation of the topography, and might often point to lands which are worthy of cultivation and improvement. The Surveyor should also know something of geology, and be familiar with the relation between the rocks and the ores and soils.

An improvement in the intellectual standard and in the methods of work among our surveyors, must necessarily lead to a corresponding advancement in their social and official position.

Because we did not succeed in our first attempt to start thorough and organized geodetic work, is no reason why we should despair of being more successful in another attempt. It might not be wise to again petition the Legislature, though if any members consider this a promising line of battle it is certainly worth the attempt.

The suggestions which I wish to make, and which are prefaced by the foregoing remarks, may ultimately result in thorough, general and connected work being done, but it must be reached by slow degrees.

I would suggest that the Club issue a circular to all Surveyors in Pennsylvania, asking for their opinions as to the advisability of calling a State Convention, to be held under the auspices of the Club, either in Philadelphia or Harrisburg, in order to discuss some of the many questions as regards variations, measurements, standards, calculations, etc., in surveying. The Convention to organize for the advancement of the profession, to appoint committees whose duty it shall be to report on special subjects to a future convention, and to provide means for publications of records and results. Also to promote the profession by favoring legislation which will make it obligatory that candidates for the office of Surveyor shall undergo a rigorous examination by a Board appointed by the Governor—the position being made more of an object by pay increased in proportion to usefulness.

Also with the *ultimate* end in view of creating in each County the office of County Engineer and Surveyor (with a Central Board of Engineers in Harrisburg), whose duty it shall be to give advice in the location of new roads, to take charge, as engineer, of the construction or repairs of roads and highways, the erection of bridges, the control of streams and the carrying out of more permanent internal improvements.

I trust the Club may deem the suggestions of sufficient merit and importance to take some action upon them.

The work of the Club should not be so much the publication and discussion of abstruse problems and formulæ connected with engineering work—for the American Society of Civil Engineers provide ample and more valuable opportunities for this—but we should endeavor to improve and elevate to a higher standard the work being done about us in this City and State.

U. S. COAST AND GEODETIC SURVEY OF THE DELAWARE RIVER AT PHILADELPHIA.

Regular Meeting, April 3d, 1880.—Mr. Rudolph Hering exhibited, on behalf of Mr. Sam'l L. Smedley, the original plane table sheets of the Delaware River Survey in front of the City, from Bridesburg to Fort Mifflin, executed by the U. S. Coast and Geodetic Survey, Washington, D. C. Mr. Hering also gave a resumé of a valuable Report, by Mr. Henry Mitchell of the U. S. Coast and Geodetic Survey, which accompanied the above charts, as follows:

The growth of Philadelphia along the river front has made the question of the proper location and form of the channel, on account of the valuable riparian rights and privileges, a very important one. It must soon be settled how far the opposite shore-owners can extend their wharves. It therefore becomes necessary to determine what is the *essential* channel and its *essential* form.

In order to approach to a rational solution of the problem, Mr. Mitchell suggests an ingenious method which, it seems, is likely to accomplish the object in a more scientific manner than has heretofore been practiced. The shore line and *thalweg* being both very uncertain are both discarded, and a smooth profile is substituted, reduced from the actual soundings by a formula based upon certain type forms of section. The shore lines are thus corrected by eliminating accidental features, and the normal position of the thalweg is fixed.

The fact that *mid-area* and *mid-volume* present lines at all sharp bends and coincide only in straight reaches or at points of reversion, and that, when the river has recently shifted its bed and not supplied the material for filling up its old channel, the line of *mid-area* would not represent the line of *mid-volume*, is the great source of trouble in meeting local questions of jurisdiction and riparian title.

The form of cross-sections is dependent upon the curvature in the course of the stream. In straight reaches it is symmetrical, the apex lying midway between the shores; in bends the greatest depth lies nearer the concave shore.

In applying his method, Mr. Mitchell first seeks the foundation form at straight reaches, and then introduces into its equation elements of change calculated to correct the curve representing it, into one adapted to the form of section observed at bends, etc. The fundamental form varies in different soils, etc., but its profile seems to oscillate between the curve of sines, whose arc is 1.57 times the mean width observed (from surface to bottom), and whose maximum ordinate is 1.57 times the mean depth (from shore to shore), to the ellipse whose axial ratio is that of mean depth to half mean width. In practice the first is the most convenient. These curves, with the proper coefficients deduced, will replace the observed fundamental section by one preserving all its *essential* features without its accidental ones.

For bends the equation must be changed so that the curve will give a profile in which the centre of gravity is moved without diminution of the area. This is done by adding an element, which will reduce one part and equally increase the other, and is accomplished by adding a certain term to the equation.

Where there is a tendency of the stream to split, a third term must be added, and many devices become necessary in fitting the computed to the observed curve till no recurrent curves appear in the residuals.

Type forms, as thus found, are given by Mr. Mitchell and adapted to the Delaware in front of the City.

The practical advantages resulting from the application of these formulæ, which generalize the forms of the sections, will be—

First. To determine the normal positions of the shore lines and the *thalweg, by deducing them from all the measures of each cross-section.*

Second. To decide what feature in any cross-section has an artificial origin, or is so recent that the stream has not yet accommodated itself to the change.

Third. To decide what position of any cross-section can be permanently improved by dredging, and where dredging would only give temporary relief, if any.

Fourth. To measure, in advance, the degree to which any proposed structure would injure the channel or induce changes elsewhere.

Mr. Mitchell then proceeds to apply this method to the Delaware River, and offers many valuable conclusions. Before a second series of roundings over the whole river bed have been taken and compared with the present, in order to properly correct cause and effect, no discussion of what really are encroachments upon the stream can be final; and he therefore merely indicates in a very interesting manner how this kind of inquiry should be made.

NOTES ON TOPOGRAPHICAL MAPPING.

Regular Meeting, April 3d, 1880.—Mr. A. E. Lehman exhibited a very well executed topographical map of the middle section of that portion of the South Mountain Range included within the State of Pennsylvania.

The work shown covers an area of 83 square miles. It required 334.30 linear miles of survey, that is, 4.02 linear miles to every square mile of topography.

For every linear mile of survey made, an average of about 4 miles had to be walked, making a total distance of 1337 miles. The levels were all run by vertical angles, which, in no case, exceeded an maximum of 27°30′. Circuits of over 25 miles were made and closed within 1.50 feet. The largest circuit (35 miles) was within .60 feet.

Have since closed a circuit of 95 miles within 2.30 feet. This, however, is so close as to arouse suspicion of its accuracy; and is most probably due to the elimination of errors throughout the line.

The geological formation is azoic, consisting, for the most part, of quartzite and porphyritic rocks, chlorite schists and epedote. Rich deposits of magnetic and hematite iron ore are the economic mineral features of that district.

One hundred and seventy-six rock dips were taken and accurately located. The normal dip is S.E. and averages about 40°.

The region is thickly wooded and produces a dense undergrowth of laurel and other brush, which seriously retarded the progress of the work, requiring the services of the axeman on at least one-half of the line.

Among other obstacles encountered during the progress of the work, more exciting than technical, however, were thirteen rattlesnakes, copperheads and blaek snakes innumerable, and one panther.

During the field season my party consisted of five persons, and in the pleasant months we lived in camp.

RAPID TRANSIT IN PHILADELPHIA.

Business Meeting, May 1st, 1880.—Prof. L. M. Haupt presented his views upon this subject as follows:—

The history of all engineering, industrial and social improvements or innovations, reveals the fact that there exists a class of persons who from ignorance, conservatism, or self-interest, are actively opposed to the introduction of all such works or reforms.

So universal is this *law of opposition* that every engineer or projector of any important public work, who hopes to succeed, must make provision to meet and allay it.

Often it is by far the most difficult factor in his problem, and one before which the mere physical obstacles with which he has to contend, sink into insignificance. Matter, as it presents itself to the constructor, is usually inert and passive, whilst mind is potent and active, fickle and intangible; but an intelligent public, arguing from facts, not fancies, will readily arrive at correct conclusions and lend a willing support to any or all enterprises intended to promote the public weal. Unfortunately a large portion of the opponents of an enterprise are not open to conviction. Such are the ignorant or selfish. The conservative may, and generally do, yield at the last moment.

Opposition, then, must be expected and recognized as an element in the Rapid Transit problem as in all others, but the objections which have been urged, are, to say the least, puerile, meaningless, and almost a disgrace to an enlightened community. When the opponents of an enterprise are obliged to resort to opprobrium, to prejudice public sentiment, it is an evidence of their impotence and shows clearly that there are no valuable facts to which they can appeal in support of their cause; when it is also remembered that the objectors are, in general, largely interested in the existing ground roads, it reveals at once the animus of these public-spirited (?) citizens, and removes the pungency of their strictures.

It is a fact, proven by experience, that *facility of communication is one of the most potent elements in human progress and material development.* Volumes of evidence might be adduced in support of this proposition, but any careful observer of events will be satisfied to accept it without demonstration. Whatever, therefore, tends to facilitate intercommunication will confer a benefit upon the city and promote its prosperity. Is it not a fact that wherever there are railroads, there population is most dense and property most valuable? And are we then to argue in opposition to the facts, that the construction of a road, such as that proposed on Market and other streets, will produce an effect directly the reverse of that which all past experience shows to result? In New York the same objections were reiterated until they became threadbare, but time has proven them to be fallacious, for instead of the stores being closed and tenantless, or the buildings burned down or shaken to pieces, as was predicted, the facts are just the reverse: rents have been raised on the streets and avenues occupied by the "L" roads, and the sanitary condition of the population has been improved by enabling citizens to remove from their noisome tenements to purer air and more commodious homes at a less annual expense.

As to the contamination of the air by the smoke and gases of the engines, it may be said that it is far less injurious than that produced by the exhalations and effluvia emanating from the thousands of horses, reeking with perspiration, which are used to propel our street cars. This objection, if seriously urged, could be readily met and eliminated by the introduction of a compressed air or other motor, generating no noxious gases along the route. Such pneumatic motors have been experimented upon in New York with great success.

The strong point of the opposition seems to be based upon the statements that elevated roads *are not needed.* This objection is an echo of the past and is no more true to-day than when it was urged by the proprietors of the stage lines in support of their own interests, whilst the long-suffering citizen, who had never known or dreamed of anything better, was content to have his vitality shaken out of him by inches as he rattled over the cobbles from Kensington or Southwark to the Exchange and back.

Doubtless there are many of our wealthy merchants and professional men living

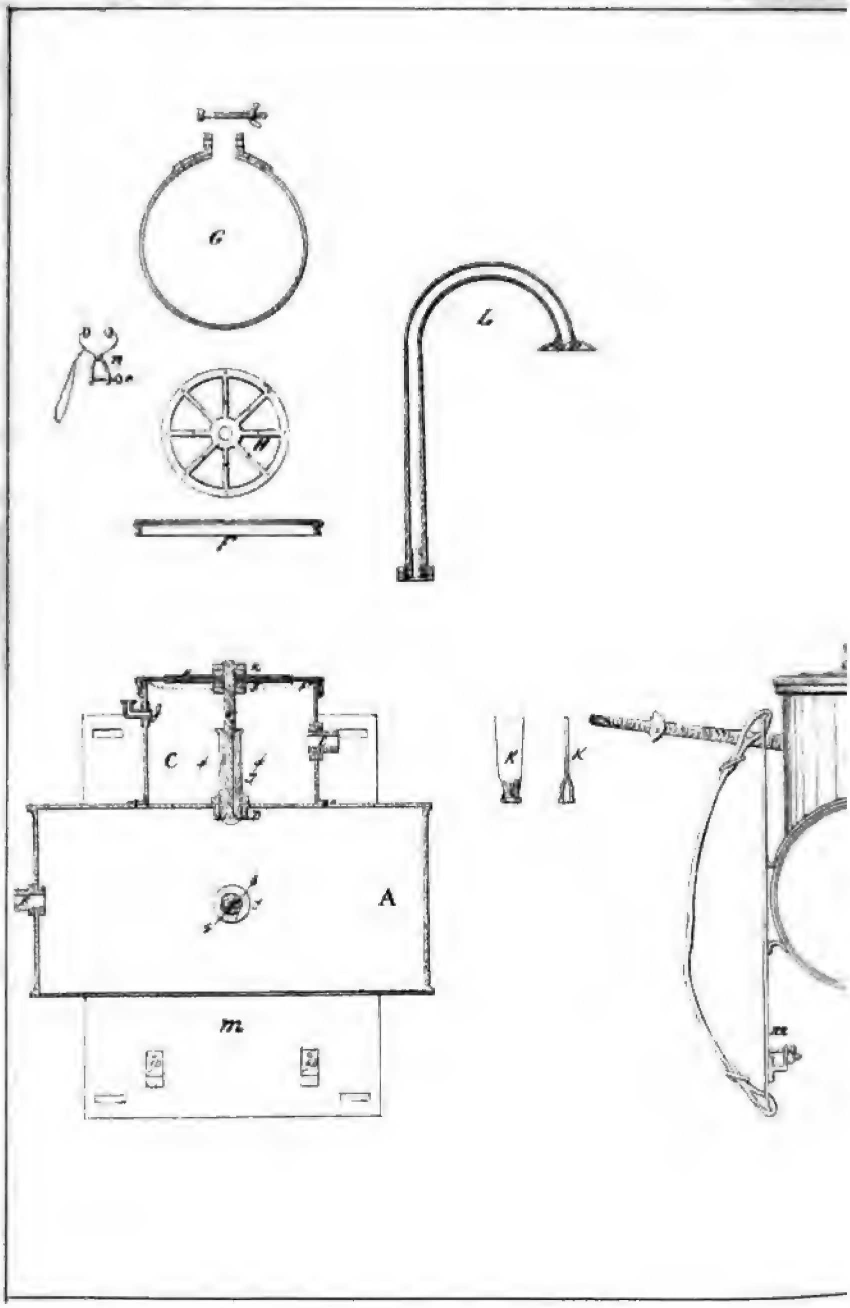
west of Broad street, who do not need and could not well use such an elevated road, were it to be constructed,—for them the walk to and from their counting-rooms or offices is necessary recreation, and in wet weather the street cars, though they are then damp and foul, are available,—to them the few minutes saved may be of no consequence. But they do not constitute the class most interested and who will derive the greatest benefit from the proposed improvement. It must be remembered that the majority of our citizens are laborers who are required to be at work at 7 A.M., and to continue until 5 or 6 P.M., and who must of necessity live near the suburbs where rents are low. To reach their shops, thousands of these artisans and mechanics are obliged to ride in cars, some from West Philadelphia to Kensington or League Island, or vice versa, many of them requiring exchanges and consuming more than two hours each day in transit. Thus, they must breakfast before five and sup after seven. The interval is left them for social life and rest. Rapid transit would save to them the most valuable hour of their day and cause no greater expense. The construction of the work itself would also benefit this important class of citizens by giving employment to a large number of skilled artisans during construction and operation, and would, moreover, attract workmen to the city, who, by their patronage, would increase the business of the retail merchants and others.

The ease and rapidity with which travel could be effected would stimulate others to move about more freely, and this in turn would react upon the trade of the city and promote its growth and prosperity.

The pleas of the opponents are more numerous than forcible, and some of them directly contradictory. For instance, it has been said that the City Councils should not grant such a *valuable* easement for a mere song, and almost in the next sentence it is asserted that no one would ride in the elevated cars, and hence the enterprise would be a miserable *failure.* Again it is urged that if such a privilege should be granted to one company it would establish a precedent for others. If the first road were a success, it doubtless would have such an effect, and the fact of its success would furnish the most satisfactory kind of evidence that there was need of it and room for it, and others would doubtless "follow as the day, the night."

The city is no longer limited by Vine and South Streets, but measures over 14 miles in length and 7 in breadth, and the sooner facilities are afforded for reaching these remote districts rapidly, just that much sooner will they be inhabited. Any obstacle to communication is a bar to progress. This is an indisputable fact, and it is a serious objection to the rectangular or "square" system of laying out streets, that persons living on the diagonal lines must waste forty-two per cent. of their time and energy in zig-zagging around corners to reach their objective *points;* for the diagonal of a square is forty-two per cent. shorter than the sum of its two sides. Hence it is evident that for the remote corners of an extensive city there should be avenues opened in the direction of the diagonals. These would become the thoroughfares, because everyone knows that "the longest way round is the nearest way home" *only* under peculiar circumstances.

At the present rates and velocities of travel it is manifest that there are practical limits from beyond which it would be unwise to expect trade, but if, by any means, the time alone could be reduced one-half, *cæteris paribus*, the distance would be doubled and the tributary area increased four-fold; or, in other words, the business of those stores situated on the line of the road would be theoretically quadrupled. This con-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clusion is substantiated by statements of New York merchants, who say their business has increased more than three-fold in consequence of the "L" roads.

The future growth of this city is contingent upon the construction of just such facilities of communication as are now proposed, and it is believed that they will merit the hearty support and co-operation of every intelligent citizen who earnestly desires to promote the comfort, convenience and welfare of his fellow man.

NARROW GUAGE RAILROADS IN THE OIL REGIONS OF McKEAN COUNTY, PENNSYLVANIA.

REGULAR MEETING, MAY 15TH, 1880.—Mr. Arthur W. Sheafer laid before the Club the following notes upon the Olean, Bradford and Warren and the Kendall and Eldred Railroads, in the oil regions of McKean County, Pennsylvania:—

The Olean, Bradford and Warren R. R. is twenty-three miles in length, connecting Bradford, McKean Co., Pa., with Olean, N. Y., and rising to a height of 2398 feet above tide, or 960 feet above Olean. Guage, 3 feet. Rails, 35 to 40 pounds per yard. Maximum grade, 185 feet per mile for 500 feet in length, and 180 feet per mile for two miles on north side of summit. Maximum curve, 30°, 350 feet in length on trestle 25 feet high.

The Allegheny River is crossed by a Howe truss bridge, of three spans, 100 feet each.

The road was commenced in November, 1877, and in sixty days trains were running between the termini.

The cost was $5200 per mile, or $7000 per mile including equipment.

The Kendall and Eldred R. R. is 18¾ miles in length, reaching from Bradford to Eldred, McKean Co., Pa.

Guage, 3 feet. Rails, 35 and 40 pounds per yard. Maximum grade, 156½ feet per mile for 2½ miles, and 136 feet per mile for 3 miles on east side of summit. Summit, 656 feet above Eldred, or 2099 feet above tide. Maximum curve, 30°. Crosses the Allegheny River on a Howe truss bridge, two spans, 90 feet each.

The road was built by contract at $3000 per mile for chopping, clearing, grading, furnishing ties and laying iron—the company furnishing the latter. Total cost, $5200 per mile.

Total cost of road, including building, buying right of way, equipment, stations, sidings for 2½ miles, etc., was $150,000.

In August, 1878, or ninety days after the running of the preliminary lines, trains were running from Bradford to Eldred.

The engines—18 tons—are calculated to haul 96 tons over the 30° curve and 156½ feet grade.

DIVING APPARATUS.—SYSTEM OF RONQUAYRAL AND DENAYROUZE.

MEETING, MAY 15TH, 1880.—Mr. J. J. de Kinder presented a description of the above apparatus.

From 1867 until 1870, while in the service of the Dutch Government, I was stationed with a corvette at Padang, on the west coast of Sumatra, one of the islands of the Indian Archipelago.

As there are no dry-docks or slips there, nearer than Batavia, some 700 miles off, so the station is provided with submarine diving apparatus, of which they have two systems:—

First, the system which is in general use in the U. S. A., viz., the rubber suit with brass helmet, etc.; and secondly, the system of Ronquayral and Denayrouze, more extensively used in Europe and almost exclusively in India.

In my capacity of engineer, I was generally called upon when surveys were held on vessels which had touched bottom, or where temporary repairs were necessary to a vessel's hull under the water-line.

As I am not aware of the use of the Ronquayral and Denayrouze or French system in the United States, I think a few words, in regard to its construction and use, may be of some interest to those who are interested in submarine diving.

The apparatus consists, first, of a thin iron cylinder *A* called the *reservoir*, which is about 8″ in diameter and about 16″ long, closed on both ends. In the centre of one end a hollow plug *B* is secured, which receives the air tube or hose when the apparatus is in use. Another thin iron cylinder-shaped vessel *C* is securely fastened onto the cylinder *A*; this is called the air chamber, and is about 7″ in diameter and about 5″ high.

D is a hollow plug, with inside thread, and opens communication between the reservoir and air chamber.

E is a hollow plug to which the air tube *L*, which conveys the air from the air chamber to the diver, is attached (this plug I have shown in the sketch as running parallel to the axis of the reservoir, in order to show it distinctly, but it should make an angle of 45° with the reservoir, to make the flexible air tube *L* lead fair to the diver's mouth.

F is a rubber cap which is fitted over the top of the air chamber *C*.

G is a copper band which, after the cap *F* is drawn over the mouth of the air chamber, forms a collar around the neck of the cap, and when screwed up tight prevents the cap from slipping and makes an air-tight joint.

The cap *F* is stiffened by means of two thin brass wheels, *H*, one on the inside and the other on the outside, and bolted together through the cap.

I is a valve box called the *controller*, as it controls the communication between *A* and *C*.

J is a light iron elbow-pipe, about ½″ in diameter, attached to the air chamber *C* and provided with a delicate rubber flap *K*. (In appearance it is somewhat similar to a long narrow paper envelope which has one narrow end slit open, and inserted into the opposite narrow end, a short ½″ tube.

The reservoir *A* is firmly screwed to a thin iron plate *M*, provided with two stout rubber straps, which enable the diver to carry the apparatus on his back like a soldier's knapsack.

N represents a pair of light padded nippers which are placed on the nose and fastened or rather tightened by means of the screw *O*. This prevents water from entering the nose.

The weights necessary to keep the diver down are attached partly to the plate *M* on the hooks *P* and *P*, and partly strapped to the thighs and to the feet, by means of heavy shoes. But these shoes, unlike those in use with the rubber suit system, are made of iron and padded on the inside. They are made in two parts; the hind part

is separate from the front part, and is kept in place by means of a stout spring, which has a projection similar to a spur. This arrangement enables the diver to remove his shoes at once if necessary, by simply pressing upon the spurs.

The following short explanation of the manner in which the apparatus is worked will enable the reader to clearly understand its points.

1st. The air pipe, which is attached at one end to the air pump, is attached to the reservoir *A* by means of the plug *B*.

2d. The controller *I* is screwed down in the plug *D*.

3d. The rubber cap *F* is drawn over the air chamber *C*, and the nuts *R*, which have previously been removed from the valve spindle *V*, are screwed back on the spindle, securing the cap tightly between the lower nuts *S* and the upper nuts *R*, so that when the cap moves, however slightly, the valve stem *V* is bound to move with it.

4th. The copper band *G* is tightened around the neck of the cap, thus preventing the escape of air from the chamber *C*.

5th. The rubber flap *K* is drawn tightly over the opening of the elbow *J*.

6th. The tube *L* is attached to the plug *E* and the apparatus is ready for use.

The diver takes the mouth piece of the tube *L* in his mouth, by resting the curved part outside of and firmly against his teeth, the lips covering it: the natural pressure of the lips makes a perfectly tight fit. In order to prevent the tube being wrenched from his mouth by some accident, the mouth piece is provided with two rubber stubs *Y* and *Y* which the operator firmly presses between his teeth. The air pump is now set to work, and as soon as the diver finds that the air supply is well up, he fastens the nippers *N* on his nose, and as soon as the weights necessary to hold him down are attached and the signal line secured, he is ready for action. The flow of air to and from his lungs takes place regularly, as follows:

The cap *F* naturally keeps the valve of the valve-stem *V* closed; the reservoir *A* is kept continually filled with compressed air. Now when the operator draws breath, a partial vacuum is created in the chamber *C*, which causes the rubber cap *F* to assume the form indicated by the dotted line; the valve stem *V* and consequently the valve is forced down and air will immediately flow from the reservoir through the opening *D* around the valve stem and through the air chamber and tube *L* to the diver's lungs. (I have made the section of the valve box and stem *V* through the line, *X–X*, below it and somewhat larger, in order to show more clearly the shape of the stem. The moment, however, that the operator stops drawing breath, the cap resumes its natural shape at once, and the valve shuts off communication between *A* and *C*. Now when he empties his lungs, he forces back the contents through *L* into the chamber *C* and through the opening *J*, and the rubber flap *K*.

The whole operation is exceedingly simple and, in my estimation, this system is far superior to the helmet system, for many important reasons.

It is much lighter in the first place. The operator picks up the whole thing (as I said before, as a soldier would his knapsack), slings the straps over the shoulder and in a moment he is ready. It takes no longer time to get rid of it than it takes to pull off a vest. To practical sub-marine divers it must be apparent that for safety the helmet system bears no comparison with this. With the suit and helmet, if for some reasons the air-pump should fail or the air-pipe break, or it and the signal line become entangled, so that his companions cannot draw him up, he must stand and drown in his shoes, and this has often occurred. But with the apparatus I have described if

the line and hose become entangled and the diver sees that he must clear himself, (if he has presence of mind and a man who has not has no business to be a diver,) all he has to do is to get where there is clear water between himself and the surface, remove his shoes and other weights (still keeping hold of them), remove the knapsack, still holding the air-tube in his mouth and finally, taking a good long breath, let go everything and he will shoot up to the surface a free and a live man. This is not theory only, for I have practised this in six and seven fathoms of water.

The only drawback that I know of against this system, is the necessity of the body being exposed to contact with the surrounding water. In the tropics this is, however, rather enjoyable, while with good heavy woollen clothing to prevent sudden chills when coming up out of the water. I am sure it is quite practical in water of a quite low temperature. I have since learned that a *light* rubber suit is manufactured now which fits tightly around the neck, and keeps the body dry. At all events but very little diving is done in the winter months.

To some the fact of keeping the eyes open under water for any considerable length of time, may appear strange and difficult. I can assure them that it causes not the slightest inconvenience, especially in salt water. I have spent many pleasant moments, quietly seated on the bed of the ocean, off the Island of Poeloe Pisang—in seven and eight fathoms of water, armed with this apparatus—picking shells with but little more inconvenience than if seated on a dry beach.

TRANSPORTING DREDGED MATERIAL.

REGULAR MEETING, JUNE 5TH, 1880.—Mr. J. J. de Kinder presented the following paper:

The great "stumbling block" connected with dredging generally is, and always has been, the question of how to get rid of the dredged material effectually and at the same time at a small cost. This, of course, depends upon the locality of operation; as, for instance, where dredging is done in a narrow river or canal, it often is possible to convey the material by means of shutes, resting on pontoons, from the dredging machine on to the land direct or on to cars.

But, where the material can not be gotten rid of this way, it becomes necessary to convey it often very long distances. It is delivered from the dredging machine into scows, which are towed away to dumping-ground. Now, where the place of operation is close to the seaboard, the dumping-ground can be in deep water, far enough away from the river mouth or bay to cause no apprehension, but where the distance from the dredger to the seaboard is very great, as for instance in Philadelphia, it is almost impossible to tow the scows to the sea, as the expense would be enormous. True, in some parts of the world, especially in some rivers in England, they employ iron steam propellor-scows, which carry the material great distances out to sea, yet, compared to the length of the Delaware, these distances are comparatively small. Consequently, where shall the stuff be dumped? If it is dumped in the river, no matter in what locality, it simply serves to spoil the channel for navigation. Of course the contractor does not worry himself about that point; just so long as he gets rid of the stuff he rests satisfied. Besides, as the channel must be kept navigable at all hazards, it follows that the more material there is thrown back in the river, the more

work there will be for the dredging machines—and, more work, more dollars. But when it is prohibited and it becomes an offence to drop dredged material in any part of the river, then there is nothing left but to put it on the land where, in fact, it really belongs, as there is generally some low land in the vicinity, or marshes, which can be dyked in and filled up to grade with these dredgings.

And now comes the question of how to get the material on land when it is impracticable to shute it off direct from the machine. Various methods have been attempted with but indifferent results. The usual way is to dump it near the river's edge or alongside of a quay or wharf, when another machine dredges it up again and deposits it in a stationary or a movable shute, which conveys it inboard or deposits it in cars, which are taken away by a locomotive. It is needless to say that this method is, at best, expensive and troublesome; while, apart from the fact that it necessitates the use of two machines, it is apparent that in dumping and digging up again the already loosened mass of material, a large percentage mixes with and is carried off by the stream, to be gradually deposited over the river bed until it becomes necessary to remove these deposits again at an extra cost.

Mr. A. E. Hall, of Boston, Mass., has invented and patented an apparatus for transporting and delivering dredged material, which is so far superior to the methods in use that it cannot fail to be, erelong, generally adopted. The said apparatus has been in use in Boston, for over a year and gives unusual satisfaction.

In said apparatus the material dredged by the machine is dumped into cars, of which there are about five on one scow or pontoon, on a single track fairly in the middle. These cars are of a peculiar construction adapted to this kind of work. They carry a load of about twenty tons on four wheels.

Further, a large pontoon carries a double bridge; that is, a bridge in two parts, which are hinged together in the centre of the bridge pontoon, and one end of the pontoon hinges on the landing and the other lies down on the car-scow. The landing is built of rows of piles, which carry a track of rails inboard to the dumping-ground. With this apparatus the material requires only one handling, consequently one machine only, and once dredged remains dredged, or in other words, no part of it goes back into the river as in the other systems in use.

The bridge pontoon is secured at the landing by the one end of the hinged bridge; the other bridge part can be hoisted or lowered by means of an overhead lever.

The locomotive required to haul the cars comes onto the bridge, the car-scow is towed, end on, against the bridge pontoon, the free part of the bridge is then lowered onto the car-scow, so that the railroad tracks on the scow, the bridge and the landing are in a line, when the load is attached and is hauled inboard. It requires but one minute to transport the cars from the scow onto the landing.

From the peculiar arrangement of the double bridge there is never any difficulty on account of the stage of the tide.

It requires no arguments to show that this system, which is now in use in Boston, is far superior to every other system in use. It kills two birds with one stone;—it improves the channel and it fills up and improves the land—with the work of one dredging machine.

THE TURNTABLE OF PENROSE FERRY DRAWBRIDGE AT PHILADELPHIA.

REGULAR MEETING, JUNE 5TH, 1880.—Mr. J. Milton Titlow presented the following:

"The bridge that is swung by means of this turntable, was built in 1878. It is a through wrought-iron roadway bridge, 21 feet between centres of trusses and without footways.

The trusses are of the double cancel Pratt system, with inclined end posts and 411 feet between lower centres thereof or about 415 feet over floor; the depth at ends is 28 feet and 38 feet at centre, the panel lengths being 15 feet except that at centre, which is 21 feet.

The four centre posts are equi-distant transversely and longitudinally of bridge and the centre line of the drum passes through each of them, it being 30 feet in diameter and 6½ feet in height.

The turntable is built so that it may be either rim or centre bearing, but at present is used as the latter.

The weight upon the four centre posts is carried to the centre bearing by means of four wrought-iron plate-girders 6 feet in depth and 30 feet long, which act as cantilerers and are placed side by side 3½ feet apart in two pairs, and at right angles; their ends being rivetted to drum under posts of trusses. One pair of girders is set some three inches higher than the other, the plates of their top flanges being continuous across and through their intersection.

Within the box or space formed by the intersection of these girders stands the cone or pivot, the point of which is about on a level with their top flanges; above this the Sellers Box with 125 lineal inches of rolling, and 56½ square inches of sliding, surfaces, and upon this the carrying plate or table.

From this heavy plate the girders are suspended from their lower flanges, by means of eight heavy bolts, and by the nuts thereon the bridge may be raised or lowered to make the table either rim or centre bearing.

Thus by simple construction with the same kind of material the weights are transferred as desired.

The live ring is formed of 51 wheels, 16 inches in diameter and 7 inches tread.

The weight of the bridge is 300 tons; when closed and loaded 576 tons: weight of turntable, tracks, etc., 79 tons.

Upon the two segments of the turntable outside of the trusses are placed, on either side, engine, boiler, etc.

On account of the small space, the engine stands parallel with the bridge, and the power is communicated, by means of friction wheels and bevel gearing, to two driving pinions on opposite sides of the rack, and to the two out end sets of screws, cams, etc., by means of which the ends are brought to bearings.

MINUTES OF MEETINGS.

OF THE CLUB.

FEBRUARY 7TH, 1880.—The regular meeting was held on this evening; Mr. Frederic Graff, President, in the chair, and twenty-seven members present.

Mr. Edward Parrish read a paper, illustrated by a map, on "The Lighthouse System of the Delaware River, from the Head of the Bay to Philadelphia;" after which a general discussion of the subject took place.

Mr. A. R. Roberts exhibited a Goniometer which had been used on the Alleghany Portage R. R.

Mr. W. G. Neilson exhibited photographs of various types of Locomotive Engines, and gave notes on their relative distribution of weight and tractive power.

Mr. Howard Murphy, on behalf of Mr. Israel W. Morris, read from Brand's History of Newcastle-upon-Tyne, 1789, extracts showing the condition of the coal trade in 1649, and giving account of very early railroad construction.

Mr. Frank T. Freeland read a paper upon a method of ascertaining the day of the week coincident with any given date, and a method for determining the years in which February has five Sundays, giving formulæ for the same.

Messrs. Chas. G. Darrach and Rudolph Hering discussed a formula for the maximum flow of rivers.

Mr. Chas. A. Ashburner announced that the Meterological Society of New York had prepared a memorial to Congress, recommending the adoption of the Metric System, and that they desired the Club to declare in favor of the same. After discussion by Messrs. Cleeman and Darrach, consideration was deferred until the next business meeting.

The Corresponding Secretary announced that the authorities of the Post-office had decided that the Club was not entitled to the benefit of "pound rates" on the Proceedings; and that some of the members of the Club had decided to frequent the Club-

rooms on the Saturday evenings when no meetings are held, for the purpose of social intercourse.

FEBRUARY 21ST, 1880.—The regular meeting was called to order by Mr. Frederic Graff, President; nineteen members and two visitors present.

Mr. Howard Murphy read a description of an instrument invented by Mr. T. A. Matsdaira, a Japanese engineer, for the solution of trigonometrical problems.

The Tay Bridge disaster was discussed, articles from the Edinburgh *Scotsman* and *Engineering News* being read.

Mr. Harold A. Freeman described an instrument for determining the position of slope stakes, on railroad work, where the ground slopes regularly.

Mr. Howard Murphy opened a discussion upon the desirability of diminishing the labor of computing the volume of prismoidal forms of earthwork, by the expenditure of some of the mathematical talent of the Club upon an instrument of the nature of the Polar Planimeter. Mr. L. M. Haupt referred to short methods now available.

MARCH 6TH, 1880.—The March business meeting was held this evening, President Graff in the chair. Twenty-four members were present.

The Corresponding Secretary read a letter from Mr. John C. Trautwine, acknowledging his election as Honorary Member of the Club, and expressing his interest and congratulations; and reported the additions to the Club literature.

The minutes of the Board of Directors for February 7th were read.

Mr. A. R. Roberts announced that one of the Honorary Members purposed presenting a valuable addition to the Club library.

Messrs. Augustus Mordecai and John H. Dye were elected Active Members; and the resignations of Messrs. C. E. Buzby, H. C. Lewis, T. J. Lewis, C. F. Moore and E. B. Wall, were read and accepted.

Mr. P. F. Brendlinger's request to be transferred to the Corresponding list, was read and referred to the Corresponding Secretary for reply.

Mr. A. R. Roberts spoke of a Club reception to M. de Lesseps, and the President, after being moved to appoint a Committee, to act in conjunction with himself, in making the necessary inquiries and arrangements, announced Messrs. C. A. Ashburner, A. E. Lehman, L. C. Madeira, Howard Murphy, and A. R. Roberts, as the Committee.

Mr. L. M. Haupt exhibited a specimen of paper, printed with faint lines, for isometric sketching; and Mr. Frederic Graff an instantaneous photograph of a submarine explosion, together with a description, which was read by the Corresponding Secretary.

March 20th, 1880.—Mr. Frederic Graff, President, called the regular meeting to order. Members present numbered thirty-three; visitors, three.

Mr. Francis L. Miller read a paper on "Recent Improvements in Percussion Rock Drills," illustrated by numerous drawings.

Mr. J. J. de Kinder read a description and exhibited drawings of an improved apparatus for discharging heavy cargoes and ballast.

Mr. C. E. Billin spoke of the importance of the Geodetic Survey of Pennsylvania, and suggested that the influence of the Club be used for the general improvement of methods and results in land surveying in the State. Messrs. L. M. Haupt, P. Roberts, Jr., A. R. Roberts, and A. E. Lehman, discussed the subject, especially deprecating the use of the magnetic needle. Official action was necessarily delayed until the regular business meeting.

Mr. Percival Roberts, Jr., exhibited a section of a partly punched cold-punched nut, etched by acid, to show the solid metallic flow, and showing, by the diminished percentage of iron leaving the hole, that a cold-punched is much stronger than a hot-punched nut.

Mr. C. G. Darrach read from *Engineering* a criticism upon his estimate of the quantity of water which will be required in the near future in Philadelphia, and made remarks in support of his views.

Mr. Frank T. Freeland read a paper on "A Machine for the Solution of the Equation of the Nth Degree," and exhibited a machine for the solution of Quadradic Equations and capable of giving the real parts of imaginary roots.

Mr. L. M. Haupt presented a lithograph of the U. S. Coast Survey Chart of the Delaware river, from Bridesburg to Fort Mifflin, which he had obtained for the Club.

April 3d, 1880.—At the regular meeting held on this evening, Mr. Percival Roberts, Jr., Vice-President, occupied the chair, and fifteen members were present.

On behalf of Mr. Samuel L. Smedley, Mr. Rudolph Hering read extracts from the Report of Mr. Henry Mitchell on the Survey of the Delaware River at Philadelphia by the U. S. Coast and Geodetic Survey, a discussion of which, by Messrs. A. R. Roberts, Wm. A. Ingham and L. M. Haupt, then took place.

Mr. A. E. Lehman submitted a lithograph of a topographical map of the middle section of the South Mountain Range in Pennsylvania, and gave figures showing the labor necessary to make surveys of this kind.

Mr. Howard Murphy, for Mr. Sam'l L. Smedley, exhibited a copy of Robert Fulton on "Small Canals and Iron Bridges," a very valuable book, both as a curiosity in engineering literature and as a Revolutionary relic—it being the identical copy presented by the author, in a letter upon the fly-leaf, to Gen. Washington, and containing the autographs of Washington and Robert Fulton. A list of the inventions of Fulton was also read from his biography.

Mr. Arthur W. Sheafer exhibited a diagram prepared by Mr. P. W. Sheafer, of Pottsville, Pa., showing the progress of the anthracite coal trade; also a diagram showing an estimate of the relative proportions of marketable and waste coal, based on the present methods of mining and preparing. It is stated that for every ton sent to market two tons are wasted.

The success and economy of the use of coal dust as fuel, were discussed by the meeting.

Mr. A. R. Roberts exhibited a working model of a new self-adjusting crossing frog, designed by himself, and made for the Philadelphia and Reading R.R., noticing the objections to the ordinary crossing and the manner in which they had been overcome.

Mr. Frank T. Freeland explained the method of determining the years in which a given day of the month will fall on a given day of the week.

A letter was read from President Graff, in which he presented to the Club a framed lithograph of the machinery and buildings of the Old Centre Square Water-works in Philadelphia.

April 17th, 1880.—A regular meeting this evening was called to order by President Frederic Graff. Seventeen members and one visitor present. A letter from Mr. John Bogart, Secretary of the American Society of Civil Engineers, inviting the Club to attend their Annual Convention at St. Louis, was read and the invitation gratefully accepted.

Mr. Coleman Sellers, Jr., read a very interesting history and description of the Mexico and Vera Cruz R. R., profusely illustrated with pictures and maps.

Mr. Chas. G. Darrach read an extract from a law recently passed by the Wisconsin Legislature, prohibiting the deposit, in any of the rivers of Milwaukee, of any sewage or matter injurious to health, and spoke upon the sewerage system which he had suggested in 1876, and which has been published in the *Report of the Chief Engineer of the Water Department for* 1876, pp. 25 to 27.

May 1st, 1880.—A business meeting this evening; Vice-President Percival Roberts, Jr., presiding; seventeen members and two visitors present.

The Corresponding Secretary gave a summary of the business of the Board of Directors.

Messrs. J. Godolphin Osborne, John Graham, Jr., Chas. T. Thompson, John L. Ogden, Andrew B. Leuffer, Harry Birkinbine, C. S. d'Invilliers, Jas. T. Halsey, Chas. W. Buchholz, John T. Boyd and Linwood O. Towne, were elected active members.

The Corresponding Secretary read a letter from Mr. Chas. E. Billin, containing the following:—

Mr. President and Gentlemen:—The present condition of the profession of land surveyor in our State, the want of *accurate* knowledge in regard to county and other boundaries, and the very erroneous county and state maps current, are a disgrace to Pennsylvania and to its engineers. The Club can not possibly undertake any more needed work of reform and improvement.

The attempt to improve upon present methods and results in

any engineering work, however humble, should call forth hearty approval and earnest work from the Club.

In furtherance of the remarks and suggestions which I made at the meeting of the Club held March 20th, I would respectfully move:

That a Committee of five members be appointed by the Chair, who shall take into consideration the subject of the improvement of the present methods of land surveying, the better location of county and other boundaries, and the collection of information in regard to the geography and topography of the several portions of the State.

That they shall be empowered to take such action as may appear to them, will lead to the best results in the promotion of the end in view, provided, that they shall incur no expense to the Club, except under special appropriations.

[The resolution contained in the above was adopted.]

(The President subsequently appointed, as this Committee, Messrs. Saml. L. Smedley, Lewis M. Haupt, John H. Dye, W. C. Cranmer and Chas. E. Billin, Chairman).

Mr. Chas. G. Darrach submitted the following Resolution, which was adopted:—

Resolved, That the President be requested to appoint a Committee of five, one of whom to be the Chief Engineer and Surveyor of the City, to study and suggest a plan of improved sewerage for the City of Philadelphia, and the protection of the rivers from pollution.

Mr. L. M. Haupt read a paper upon Rapid Transit in Philadelphia, arguing in favor of the proposed elevated roads.

May 15th, 1880.—President Graff called the regular meeting to order; twenty-four members were present.

Mr. Arthur W. Sheafer read notes on narrow gauge railroads in McKean County, Pa., and Mr. W. G. Neilson spoke of the Chicago and Tomah R. R. (narrow gauge) on which 20 ℔. rails were used even on 25° curves, and heavy Mogul engines and trains of seven cars, each of thirteen gross tons weight, had in the several months of the operation of the road, caused surprisingly little wear and tear.

Mr. A. R. Roberts stated the results of a recent trial run between Philadelphia and New York, on the Bound Brook Railroad.

Mr. J. J. de Kinder described the Ronquayral and Denayrouze diving apparatus.

Mr. Frank T. Freeland called attention to a new form of link valve motion published in *Engineering*, and gave a formula for calculating the travel of the valve. He also made a determination of the percentage of vacant space in a pile of spheres, giving a result of about 26 per cent. in either a triangular or square pyramid.

Mr. L. M. Haupt thought this might be practically applied in the mixing of concrete.

Mr. Haupt also read an abstract of a pamphlet by Genl. Herman Haupt, upon a new design for the improvement of the navigation of shallow rivers.

A letter was read from Mr. A. M. Wellington, of the Society of Civil Engineers of Cleveland, suggesting a common publication by all the Engineering Societies of the U. S.

June 5th, 1880.—Regular meeting this evening; the Vice-President, Mr. Percival Roberts, Jr., in the Chair; eighteen members and one visitor were present.

Mr. David Townsend read a paper on a new method for the quantitative determination of carbon in cast iron and steel, and exhibited the apparatus for that purpose.

Mr. J. J. de Kinder read a paper on an improved apparatus for transporting dredged material designed by Mr. A. E. Hall, of Boston.

Mr. Howard Murphy, on behalf of Mr. J. Milton Titlow, read a paper upon, and exhibited the drawings of the turntable of Penrose Ferry Bridge, Philadelphia.

Mr. Rudolph Hering read a paper on a system of intercepting sewers to prevent the pollution of our rivers, comparing his system with that of Mr. Darrach, and giving estimates of the probable cost and efficiency of the two systems.

A letter from Mr. A. M. Willington, concerning the scheme of joint publication, was read.

June 12th, 1880.—A special meeting was held this evening for the purpose of adjourning the meetings of the Club for the summer months. It was so ordered, the Club to reconvene at the call of the President.

of the Board of Directors.

February 7th, 1880.—A special meeting was held this evening. The resignation of Mr. Chas. E. Billin as Corresponding Secretary and Treasurer of the Club was accepted; and Mr. Howard Murphy elected Corresponding Secretary, and Mr. A. R. Roberts, Treasurer. This election of Mr. Murphy leaving a vacancy in the Board of Directors, it was filled by the election of Mr. Herman Hoopes a member thereof. The Committees on Library and Finance were then changed to the following:—

On Library.—Messrs. John A. Wilson and Herman Hoopes.

On Finance.—Messrs. Coleman Sellers, Jr., and Herman Hoopes.

February 21st, 1880.—Monthly meeting. Routine and unimportant business was transacted.

March 20th, 1880.—Monthly meeting. Sundry bills were approved, and the Corresponding Secretary authorized to make such purchases as were necessary for the transaction of the business of his office.

April 17th, 1880.—Monthly meeting. Sundry bills were ordered to be paid, and a form of instructions to members of the Committees on Information was discussed.

May 15th, 1880.—Monthly meeting. Routine business was transacted.

A letter was read from Mr. A. M. Wellington, suggesting that this Club participate in the proposed joint publication of the Engineering Clubs of the country, and the Corresponding Secretary was ordered to reply. Bids were opened for the printing of the next volume of the Proceedings of the Club, and the contract was awarded to the Globe Printing House.

September 18th, 1880.—Monthly Meeting. The resignation of Mr. Rudolph Hering as a member of the Board, on account of his absence in Europe, was read, but upon motion, it was not accepted.

CONTRIBUTIONS TO THE LIBRARY.

To August 31st, 1880.

Correction.—In Vol. I, No. 5. of these Proceedings, the "Geological Survey of Canada," 21 vols. and Maps. was erroneously acknowledged. The Club is indebted to Mr. Alfred R. C. Selwyn, Director of the Geological Survey, for this valuable contribution.

From the INSTITUTION of CIVIL ENGINEERS. Mr. James Forrest, Sec'y, London.
President's Address, January 13th, 1880.
Abstracts of Papers in Foreign Transactions and Periodicals—Session 1879-80. Vol. LIX, part 1. Vol. LX, part 2. Vol. LXI, part 3.
Hill—Two Drainages in Ireland.
Wood—Tunnel Outlets for Storage Reservoirs.
Sleeman—The Delta of the Rhine and the Meuse in the Netherlands.
Blandy—Dock Gates.
Duckham—The Thames Steam Ferry between Wapping and Rotherhithe.
Gaffenried—The Regulation of the Waters of the Jura.
Jackson—Dredging Operations on the Danube.
Agudio—A Rack Railway worked by Endless Ropes.
Clericetti—The Theory of Modern American Suspension Bridges.
Baker—The River Nile.
Blackett—New Zealand Lighthouses.
Keating—Fire Hydrants.
Wilson—Monongahela River Bridge.
Webster—Iron and Steel at Low Temperatures.
Vernon—Harcourt and Buckley—Fixed and Movable Wiers.
Delano—Use of Asphalt and Mineral Bitumen in Engineering.
Blyth—The Caledonian Railway Viaduct over the River Clyde, at Glasgow.
Westland—The Calder Viaduct.
Abel—Explosive Agents Applied to Industrial Purposes.
Gower—Abingdon Sewerage.
Chatterton—Main Drainage of Torquay.
Roberts—The San Francisco River, Brazil.
Jones—The Purification of Gas.
Baker—Cleopatra's Needle.
Stooke—Rural Water Supply.
Attwood—The Chile Vein Gold Works, South America.
Rymer—Jones—The Temnograph.
Newman—A New Snow Plough.
Willotte—The Removal of Sunken Rocks in Brest Harbour.
Lucas—Hydrogeology of the Lower Greensands of Surrey and Hampshire.

From the SOCIETY of ENGINEERS, London.
Mr. P. F. Nursey, Sec'y.
Transactions for 1879. 1 vol., bound.

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Mr. H. Trueman Wood, Sec'y.
The Journal—Weekly.

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Mr. W. J Millar, Sec'y, Glasgow.
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M. Husquin de Rhéville, Sec'y.
Mémoires—Nov. and Dec., 1879; Jan., Feb., March, April, May, June, July, Aug., 1880.

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Editor: Dpl. Ing. Josef Melan, Vienna.
Wochenschrift.
Zeitschrift. Part XII, 1879. Parts I, II, III, IV, V, VI and VII, 1880.
Gustav Ritter von Wex—Second Treatise on the Decrease of Water in Springs, Creeks and Rivers Contemporaneously, with an Increase in Height of Floods in Cultivated Countries.

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Proceedings—1879, second half.

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Mr. C. A. Angström, Sec'y.
Sjette Häftet, 1879; Forsta Häftet, Andra Häftet and Tredje Häftet, 1880.

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Mr. A. Direccao, Sec'y.
Proceedings—Nov. and Dec., 1879; Jan., 1880.

From the EDITORS AND PROPRIETORS, MESS. A. A. C NEVES and F. L. T. C. da SILVA, Lisbon.
O Constructor. 1st Series, Nos. 1, 2, 3 and 6.

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D. Eduardo Aguirre, Sec'y, Buenos Ayres.
Anales—Jan., Feb. (2), April, May and July, 1880.

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Mr. John Bogart, Sec'y, New York.
Transactions. Dec., 1879; Jan., Feb., March, April, May, June, July and Aug., 1880; and List of Members.

From the AMERICAN INSTITUTE of MINING ENGINEERS.
Mr. Thomas M. Drown, Sec'y, Easton, Pa.

Morris—The New River Coal Field of West Virginia.
Platt—Note on the Defreest Journal-Bearing.
Raymond—A New Method of Dredging, Applicable to Some Kinds of Mining Operations.
Egleston—The Law of Fatigue and Refreshment of Metals.
Spilsbury—A New Air-Compressor.
Kimball—Atmospheric Oxidation or Weathering of Coal.
MacFarlane—Silver Islet.
Wurtz—Fuel Gas, and the Strong Water-Gas System.
Mell—The Claiborne Group and its Remarkable Fossils.
Holley—Notes on the Siemen's Direct Process.
Merritt—The North Staffordshire Coal and Iron District.
Loiseau—The Successful Manufacture of Pressed Fuel at Port Richmond, Phila., Pa.
Church—The Heat of the Comstock Lode.
Hartman—Notes on the Blast Furnace.
Kennedy—Blast Furnace Working.
Roberts—The Puddling Process Past & Present.
Boyd—The Mineral Resources of South-eastern Virginia.
Richards—Notes on Battery and Copper-Plate Amalgamation.
Proceedings of the annual meeting held in New York, February, 1880.

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MR. JAMES M. SWANK, Sec'y, Philadelphia.
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The Duty on Steel Rails—The Case for the Manufacturers before the Ways and Means Committee, House of Representatives, February, 1880.
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Also the following Tariff tracts:
Welsh—Free Trade and Protection.
Dudley—What Protection has Done for the United States.
Stebbins—A Tariff is Not a Tax.
Editorial in the Bulletin—Who is Augustus Mongredien?
Our Foreign Commerce since 1861.
Short Essays on Protection.
Open Letter to John Bright—The "Barbarism" of Protection.
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MR. JOHN BIRKINBINE, Sec'y, Philadelphia.
Journal. August, 1880.

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MR. S. E. TINKHAM, Sec'y, Boston.
Records of Meetings. Sept., Oct., Nov. and Dec., 1879; Jan., Feb., March, April and May, 1880.
Constitution, By-Laws, List of Members and Metric Committee's Report.

From the ENGINEERS' SOCIETY of WESTERN PENNSYLVANIA.
MR. JAMES H. HARLOW, Sec'y, Pittsburgh.
Metcalf—Why Does Steel Harden?
Harlow—Description of a Derrick Used at Davis Island Dam.

Roberts—The Allegheny River.
Kent—The Metric System.
Gottlieb—The Tay Bridge.
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Mahan—The Metric System.

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MR. J. P. LESLIE, Librarian.
Proceedings. July to December, 1879; January to March, 1880.

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Rosengarten—Reform Schools.
Kellogg—Thoughts on the Labor Question.
Ray—Isolation of Persons in Hospitals for the Insane.
Whitney—Public Schools in their Relations to the Community.

Hodge—The Philadelphia Society for Organizing Charitable Relief and Repressing Mendicancy.
From the FRANKLIN INSTITUTE, Phila.
DR. ISAAC NORRIS, Sec'y.
Journal—Feb., March, April, May, June, July and August, 1880.

From the U. S. COAST and GEODETIC SURVEY.
HON. C. P. PATTERSON, Superintendent.
J. E. HILGARD, Assistant in charge of Office.
Reports. 1871., 1872, 1873, 1874. 4 vols., bound.
Report. 1876. Bound.

From ENGINEER DEPARTMENT, U. S. ARMY.
Mendell—Report upon the Blasting Operations at Lime Point, California, in 1868 and '69.

From the WAR DEPARTMENT.
Brown—Annual Report upon Improvement of South Pass of Mississippi River.

From the DEPARTMENT OF THE INTERIOR.
Report of Auditor of Railroad Accounts. 1879.

From PROF. C. A. ANGSTROM, Stockholm.
Angström—Handbook för Beräkning och Byggnad af Turbiner och Turbin—Pumpar. 2 vols., text and plates.

From MR. P. H. BAERMANN, C.E., West Troy, New York.
Canal Commissioners of State of New York. Annual Report for 1875. Bound, with Maps.
Baermann—Report to Water Commissioners of Richfield Springs. January, 1879.
Baermann and McAlpine—Report to Troy Water Works Company, 1876.
Stereoscopic Views of Concrete Machine and Inlet and Waste Valves.
Dehli and Middletown R. R.—Specification, Contract and Estimate.
Johnstown Water Works—Specifications, Proposals, Rates, Rules, etc.
West Troy Water Works—Specifications and Estimates.
Pier in Harbor at Whitehall—Specification.
Enlargement of Erie Canal, 1849—Piers and Embankments Specifications.
New York State Canals, 1854—Aqueduct Specifications.
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Baermann—Report on Water Works for Oxford, N. Y., 1879.

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Statistics and Information, Trade and Commerce. Buffalo, 1874.
Niccol—The Sugar Insect. Philadelphia, 1868.
Special Commissioner of the Revenue—Report upon Industry, Trade, Commerce, etc., of U. S. for 1869.

From
The San Francisco River—Abstract of Report of Hydraulic Commission of Brazil, W. Milnor Roberts, Chief Engr.

From MR. SAMUEL H. YONGE, C.E.
Yonge—Testimony at the Coroner's Inquest of the St. Charles Bridge Disaster.

From MR. P. W. SHEAFER.
Sheafer—The Anthracite Coal Fields of Pennsylvania and their Exhaustion.

From MR. WM. A. INGHAM (member of the Club), Secretary of the Board of Commissioners.
Second Geological Survey of Pennsylvania Reports, P2, Q2 and Q3.

From DR. WM. H. McFADDEN, (member of the Club).
McFadden—Report of Chief Engineer of Philadelphia Water Department, 1879.

From MR. JOHN C. TRAUTWINE, C.E., (Honorary member of the Club).
Trautwine — Engineers' Pocket Book — 1881, bound.

From MR. MONCURE ROBINSON (Honorary member of the Club).
Robinson—Obituary Notice of Michel Chevalier.

From MR. ERNEST PONTZEN (Corresponding member of the Club).
Level—Les Chemins de Fer devant le Parlement l'exploitation par l'état et par l'industrie privée.
De Franqueville—L'état et les Chemins de Fer en Angleterre.
Pontzen—Chemin de Fer de L'Arlberg.

From MR. FREDERIC GRAFF (member of the Club).
Watuppa Water Board—6th Annual Report—1880.
Lowell Water Board—7th Annual Report—1880.
Centre Square Water Works, Philadelphia—Lithograph, framed.

From MR. J. J. DE KINDER (member of the Club).
A. E. Hall's Pontoons for Transporting Dredged Material—Two large Photographs, framed.

From MR. CHAS. E. BILLIN (member of the Club).
Gautier—Dephosphorization of Iron. Translated by Chas. E. Billin.
Commissioner of Agriculture—Handbook of Virginia, 1879, P. Soc. Sci'.
M. Collignon—Enveloppe des Ellipses Planétaires.

From PROF. L. M. HAUPT (member of the Club).
American Engineer—Nos. 1 and 2
Haupt—Improvement of the Ohio River.
" —Lithograph of U. S. Coast and Geodetic Survey of the Delaware River at Phila.

LIST OF MEMBERS,

Additions.

MORDECAI, AUGUSTUS, N. Y., P. & O. R.R., Cleveland, Ohio.
Elected March 6th, 1880.

DYE, JOHN H., Survey Dept., Phila. " " "

OSBORNE, J. GODOLPHIN, Pearisburg, Giles Co., Va.
Elected May 1, 1880.

GRAHAM, JOHN, JR., Pearisburg, Giles Co., Va. " " "

THOMPSON, CHAS. T., 1057 Richmond St., Phila. " " "

OGDEN, JOHN L., 72d and Greenway Ave., " " " "

LEUFFER, ANDREW B., 2036 Mt. Vernon St., " " " "

BIRKINBINE, HARRY, 152 S. 4th St., " " " "

d'INVILLIERS, CAMILLE S., Lancaster, Pa. " " "

HALSEY, JAS. T., 1359 Ridge Ave., " " " "

BUCHHOLZ, CHAS., W., 227 S. 4th St., " " " "

BOYD, JOHN T., Rogers Locomotive Works,
Paterson, N. J. " " "

TOWNE, LINWOOD O., 221 S. 38th St., Phila. " " "

NOTE.—A complete revised list of members will be published, in which all changes and corrections may be seen.

BOOK NOTICE.

EXPERIMENTS ON THE STRENGTH OF WROUGHT IRON AND OF CHAIN CABLES. By Commander L. A. Beardslee, U.S.N. Revised and abridged by Wm. Kent, M.E. John Wiley & Sons.

Under the above title, Mr. Wm. Kent has given us, in a compact form, for ready reference, the important conclusions arrived at upon the subject of Wrought Iron by the United States Test Board. It is unnecessary to speak of the results enumerated, as their great value and trustworthiness are universally recognized. It is a book which should be thoroughly examined by all doing work in iron for structural and other uses; and its contents are but another strong point in the argument for the continuation by Congress of a Board whose labors, at the very beginning, were crowned with such great success.

Vol. II., No. 2.

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PROCEEDINGS

OF THE

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ORGANIZED DECEMBER 17th, 1877.

Vol. II.] FEBRUARY, 1881. [No. 2.

ANNUAL ADDRESS

Of Frederic Graff, Retiring President.

Read January 8th, 1881.

Gentlemen:

It is not my intention to attempt to give you an exhaustive catalogue, or detailed description, of all the many engineering works worthy of mention, that have been projected, commenced, or accomplished during the past year, though such a course is usual on occasions like the present. I propose to tax your patience for a short time, by simply naming, and briefly describing, some few only of such works as have attracted the attention of engineers and the public.

Of the proposed schemes, perhaps those relating to the construction of an inter-oceanic canal, have created the largest share of interest. The details of the plan and route, for a canal without locks, proposed by Monsieur de Lesseps, and others which have been suggested by it, or have preceded it and are now revived, have been freely placed before the public. Those of you who have paid attention to the subject, are well acquainted with them, and are also familiar with the plan of Capt. Eads

for a ship rail-road to effect the same object, as he alleges, with less first cost, and greater advantages in speed and convenience.

These are grand schemes, and are now being vigorously urged by their respective champions; one or other of the plans proposed, will doubtless be commenced this year. Their relative merits have been fully discussed before several of the engineering societies of this country and Europe. It is evident from the information thus brought out, and the examinations and surveys made of the different locations proposed, that there are no difficulties, on either of them, that cannot be successfully overcome, by the engineering talent, energy and facilities of the present day.

We have only to turn to the consideration of the work accomplished in the construction of the great mountain railway tunnels of our own country and Europe, to be convinced of this. The Hoosac, Mt. Cenis and St. Gothard, are notable examples of what may be accomplished.

The St. Gothard, now approaching completion, is thus far the grandest: fully two-thirds of the total length of the tunnel proper is entirely finished, ready for use: the enlargement of the balance is so far advanced that it is estimated it can be completed early in April next.

The approaches to the tunnels are of themselves great works, comprising some fifty-two smaller tunnels, having a total length of sixteen miles, nearly all of which are pierced, and about one-half now completed: up to September 30th, 1880, about $16,526,000 had been expended, of which $9,970,000 was for the tunnel proper, and $6,556,000 upon the approaches. The success of the Mt. Cenis tunnel and the anticipated future usefulness of the St. Gothard, has lead to the contemplation of others of like character, through the Alps.

A tunnel is now proposed through the Simplon, which, if constructed, would shorten the distance between Paris and Milan at least one hundred and twenty miles, and by adopting a route through Mt. Blanc (also proposed) this distance can be still further considerably reduced. It is believed that neither of these schemes present greater difficulties than that nearly accomplished at St. Gothard: the relative lengths of these tunnels will be, ap-

proximately, about 7½ miles for Mt. Cenis, 9¼ for St. Gothard, 12 for Simplon, and 8½ for Mt. Blanc.

The expense cannot, however, be measured by the respective lengths of the tunnel proper; the approaches and other items incidental to the individual requirements, will make marked differences in this particular.

Works of this character, gigantic and difficult as they appear, no longer astonish us; in fact no work of the kind is considered too bold or extensive for our engineers to undertake. Their ingenuity in devising and adapting new machines and appliances for effecting their purpose economically and rapidly, is truly wonderful.

The use of drilling machines worked by compressed air and the employment of dynamite and other rapid explosives, make work of this character feasible now, that would, only a few years back, have been impossible. I think we may confidently look forward to the time, when the whole face of rock tunnels may be driven at one operation, and probably by the use of comparatively much smaller quantities of explosives.

One of the works started during the past year, (which, had it been proposed a few years since, would have been startling in the highest degree,) is the project of tunneling under the Hudson river, by the aid of compressed air. The success in sinking caissons for the construction of the piers of the St. Louis, Brooklyn and other of our stupendous bridges, by this means, probably led to the adoption of this plan, though the use of such means is not without precedent, for we have record of a tunnel having been thus driven in Europe, through quick-sand;—of limited length and size, it is true, the main difference being, that the air lock was placed vertically in the shaft, instead of horizontally, whereby an important element of safety to the men employed was secured.

The Hudson river tunnel was certainly started with an apparent recklessness, and disregard of proper precaution and precedent, that cannot be too strongly condemned.

The use of compressed air is rapidly increasing, and although much improvement has been made in the engines and means of producing the pressure, as well as in the drills, and other appli-

ances in which it is utilized, we have still to hope for further advance in perfecting the air compressing machinery.

A suggestive application of compressed air was made in one instance, to the successful cleansing of a reservoir, in which was a large accumulation of silt. The method employed was by means of a pipe and gum hose, carried upon a scow, the pipe having a perforated nozzle, through which air compressed under a tension of eighty-five pounds to the square inch, was forced by an engine of eight horse power. The silt was thus loosened and stirred up, and then flushed through the sluices of the reservoir, the pressure was kept up by the use of an accumulator.

Some modification of this plan could, I think, be used to advantage in cleansing out sewers in which silt has accumulated.

The application of compressed air to motive power for street rail-roads, has not yet proved sufficiently perfect or economical to meet with adoption.

It has recently been proposed to supply power commercially, for small motors for domestic purposes, the compressed air being supplied from a central station, distributed through suitable street mains, and taken off where desired, at a fixed rate of charge. Hydraulic pressure has also been proposed to be applied for similar purposes, for cranes and passenger elevators, the waste water to be returned by a second line of pipes to the reservoir at the pumping station, this latter course only being necessary where the public water supply is limited, and the charge for its use excessive.

Hydraulic pressure produced by the head upon the street mains of some of our cities, created by tanks on the tops of the houses, or by the intervention of accumulators, has been quite generally applied as motive power for passenger and other elevators, in our hotels and store houses. Many such have been erected during the past year; it supplies a smooth, safe and convenient power for this purpose.

The use of hydraulic cranes have not increased as much as might be expected, although now almost exclusively and advantageously employed, in the extensive steel works of this country.

To the railways of our country there have been added in the past year not less than seven thousand five hundred miles, making

the aggregate length now in use, more than eighty-three thousand miles. The length of track laid last year is greater than ever before laid in one year, in the United States or any other country.

Much improvement has been made in the character of the permanent way, rolling stock, and conveniences of travel on most of our railways, but sufficient attention has not yet been paid, to increasing the safety of passengers, and reducing the possibility of accidents, by the adoption of the block system, with interlocking switches and signals.

Narrow gauge roads have increased, particularly in parts of the west, where it is desirable to develop the resources of the country rapidly, and in rugged and difficult locations, where wider roads would be impracticable at any reasonable cost. An instance which came under my notice is the road up Clear Creek Cañon, Colorado, to Central City, Georgetown, etc. At Central City an altitude of over eight thousand feet above the sea, is reached by a road of three feet gauge, carried up the very precipitous side of the mountain, by a series of switch-backs of the boldest character.

It is estimated that there are now over five thousand miles of narrow gauge roads in this country. Their employment in Europe is also increasing, where there are now in use nearly twenty different widths, ranging from eighteen inches to forty-eight inches; the metre and three feet six inch gauge being the most used.

In Europe, on very steep grades, the rack and pinion roads, somewhat like that on Mt. Washington, have been adopted, in some eight or ten cases.

In Switzerland there has been built one road, employing what is called the water balance method, on an inclined plane, at the summit of which there is an ample supply of water. It is a double track, upon which one train rises, and the other descends, the two being attached to a steel wire cable, passing over a large sheave: the descending train has its tanks (which are under the cars) filled with sufficient water, to draw up the loaded train on the opposite track. This, where the water supply is ample (as in the case mentioned) is a simple and economical method of surmounting elevations of limited altitude and length.

As a means of transportation upon street roads, that employed on several of the steepest streets in San Francisco may have mention, and be described as follows: a steel wire cable, about one inch in diameter, and in one case sixteen thousand feet long, passes over sheaves placed at intervals of forty feet, in a small tunnel placed under the surface of the street, between the rails. The cable is kept in motion, at the rate of about six miles per hour, by a stationary engine, situate on the line of the road. A dummy or traction car, is so arranged that by means of a flat bar of steel passing through a slot three-quarters of an inch wide, made in the top of the tunnel, and a proper lever connection fixed to the car, a clutch is made to grip the moving cable tightly, when the traction car and an ordinary street car attached to it advances, of course at the same rate of speed as the cable, and by releasing the grip and applying the ordinary break, the car is stopped, as easily and quickly as an ordinary horse car.

This plan is peculiarly well adapted to San Francisco, where the grades are in many cases so great as to preclude the use of the ordinary street cars, without the aid of extra horses.

On one of the roads, an elevation of 335 feet is surmounted, in a distance of 2926 feet, and the appliances for connecting and disengaging the cars and other details of the plan, are carried out with great ingenuity and efficiency.

It is stated that the system, beside being so well adapted to the situation, is considerably less costly in running expenses, than upon roads using horses. There are now five of these roads in use, and two more are about being built.

Of course the plan would be attended with difficulty, where frost and ice are more usual, by accumulating in the tunnels, through the slots, and about the cable and the pullies upon which it runs.

The elevated street roads of New York appear to be successful and to have gained the confidence of the people as to safety, etc. It is a significant fact, showing the difference between English and American people, that the traffic upon the underground railroads of London, with its enormous population, had last year (or seventeen years after their construction) reached 60,747,000 persons per annum, on about twenty-five miles of roads. In the city

of New York with a population of about one-fourth that of London, 61,000,000 passengers were carried last year, over twenty-seven miles of elevated roads.

The kind of traffic in each case is almost identical, being simply passengers going from one part to the other of the same city.

As a means of transporting material, the hydraulic mining, so extensively employed in California, is effectual and remarkable.

Upon a grade of about a quarter of an inch to the foot, a so-called miners inch of water, equal to a flow of about 17,000 gallons in twenty-four hours, has been found capable of moving ten tons of quartz, gravel, sand and iron, to a distance of ten miles in a day, and at one gravel mine, twenty-five cubic yards of trailings were moved fifteen miles in one day. The practice is however working to serious disadvantage by filling up the small streams and rivers.

A species of hydraulic mining was applied last year to effect the removal of part of Diamond Reef, New York Harbor. The large rocks had been previously blown out, leaving a mass of hard pan, boulders, gravel and sand. This required to be moved by some means into the deep water near at hand. A powerful water jet was forced by a steam pump, through hose and iron pipe, which could be directed from a scow to the position required. By this means, much of the clay and fine material was loosened and swept into deep water by the tide, or dragged there by rakes worked by steam power on the scows.

A species of injector was afterwards used, which consisted of a pipe of large diameter, into one end of which water was pumped through a smaller pipe, and this was applied to the dirt to be removed, and the material passing with the water into the large tube through the annular space around the smaller one, and out of the other end was delivered into deep water; the pipe being placed in a horizontal position or nearly so.

A very important work in a country where there are so many rivers more or less impaired in their usefulness by seasons of low water, is the erection of movable dams, such as are now being constructed at Davis' Island, on the Ohio river, five miles below Pittsburg, and on the Kanawha river, Virginia.

The plan is largely employed upon the rivers of France, where there are now in successful use, nearly one hundred and fifty such dams.

The idea of movable dams for the improvement of the navigation, is believed to have originated in the United States with the late Canvas White, and to have first been used on the Lehigh river. They were then called "bear trap" dams and were simple, ingenious and effectual; they were constructed of wood lying flat upon the bottom of the stream in high water, were automatically raised by an ingenious arrangement of sluices, when the water in the river fell low enough to make their use necessary.

The river at Davis' Island is about fourteen hundred feet wide, the dam proper will be divided into four parts with a lock upon the bank of the river. The floor of the dam is formed on concrete with cut stone top, during high water all parts of the dam, consisting of movable wickets, rest on this bottom; behind these are a set of trestles also hinged so as to lie flat on the floor.

When the water falls, these trestles are first raised, and by planks placed upon them form a bridge, from which the wickets of the dam, one hundred in number, are raised one at a time, the four sections of the dam are of different levels, and one or all can be used checking the flow and backing up the water in the river as required. When the river falls so low as to make it necessary for all to be raised, the lock has to be used.

The lock is a fine piece of work, one hundred and six feet wide and six hundred feet long in the clear. The gates are of unusual construction, being trussed wooden structures, running upon wheels, sliding across the lock at right angles and back into proper recesses; each gate is one hundred and eighteen feet long, and will be worked by chains and drums, driven by turbine wheels.

The dam when in use will secure a long distance of slack water navigation, and create a harbor at the city of Pittsburg.

The system of steam towing by the employment of wire or chain cables laid upon the bottom of the stream, and passed around winding drums, driven by steam engines and placed upon the decks of the towing boat, is quite generally and successfully used upon the Elbe, and other rivers of Europe. The plan

has been carefully tested last year upon nearly one hundred miles of the Erie canal. It is claimed that the greater speed attainable by this method, has practically increased the working capacity of the canal, fully fifteen per cent., and is an entire success.

As a means of transporting one of the most useful products of our state, the so-called "oil pipe lines" have increased and proved a success. Oil has been forced through lines of pipe, varying from twenty-five to fifty miles in length, and a line of more than three times the latter distance has been proposed.

The pumping service for some of the lines is very severe, the pressure upon the pumps has reached between twelve and fifteen hundred pounds to the square inch, when pumping through pipes of six inches diameter, whilst their capacity is very large, varying from eight to fifteen thousand barrels each per day.

Owing to their remarkable smoothness of action, freedom from shocks, advantages which peculiarly adapts them for pumping directly into the mains, the Worthington Duplex engine, both non-condensing and compound condensing, have been much employed for this service, and proved entirely successful in all particulars.

To Boston belongs the credit of being the first city in this country, to construct a complete system of intercepting sewers, for the purpose of carrying away and disposing of the sewage, at a point where it will be entirely inocuous.

The general feature of the plan now being carried out, are the construction of an intercepting sewer around the city, receiving the flow of all the present and proposed lateral sewers. The sewage will be lifted by steam power to a height of about thirty-five feet, and then passed by an inverted siphon and tunnel under an arm of the sea to "Moon Island," upon which a reservoir of five acres area is being constructed; from this, for two hours at the proper stage of the ebb tide, it will be discharged and carried to sea.

Many and long continued experiments were made by floats, etc., etc., whereby the engineers were convinced that all objectionable matter would certainly be carried beyond the reach of harm to the city or harbor.

The district drained is about sixty square miles, about forty-

six miles of which is high enough not to require pumping, and will pass by its own sewer direct, the lower level sewer will, however, be large enough to receive the whole.

The inclination of the sewers are calculated to give a velocity of from two to five feet per second, at their minimum flow. They vary in size from the three feet egg shape to ten feet, six inches, circular, and are all built with Portland or Rosendale hydraulic cement.

The pumping station is built for eight engines, each capable of lifting 25,000,000 gallons to a height of fifty feet in twenty-four hours. Two of these engines are being built from the designs of E. D. Leavitt, and two are Worthington compound direct acting. The tunnel to "Moon Island" is one hundred and thirty-five feet below low water, nearly level, and about seven thousand feet long.

The sewerage of Memphis has been executed upon a plan now gaining attention both in this country and in Europe, the plan being to make the sewers only large enough to carry off the house drainage, and disposing of storm water over the surface or by seperate sewers.

The house sewers not receiving any storm water, flushing tanks become positively necessary; these, as built in Memphis, are small underground reservoirs of masonry, containing about one hundred and twelve gallons, supplied from the street mains, so that they may be filled once in twenty-four hours. By means of a peculiar siphon, acting automatically, they are discharged in about one minute, with a rush into the drains, thus flushing them once every day.

The system at Memphis is principally glazed pipe, from 15 to 20 inches diameter for the mains, and 6, 8 and 12 inches for the laterals. They aggregate about forty miles in length; the outlet discharges into the Mississippi below low water.

There are no man holes on any of the sewers; they are supplied with large gratings for the admission of fresh air and ventilating pipes of four inches diameter are carried at short intervals to the tops of the houses.

No house of any size is allowed a connection with the main line, of more than four inches diameter, the idea being that no

foreign matter could pass through this large enough to obstruct a six inch glazed pipe, so that if housekeepers allow their four inch connection to be obstructed, they alone will be the sufferers and not the city.

Every part of the work is said to have been carried out with the utmost care, a very essential feature when such small pipes are used, and one unfortunately not always attended to.

The system presents the attractive feature of comparatively low first cost, but it is open to several serious disadvantages, the worst, perhaps, being the dependence for cleansing upon hidden automatic arrangements of doubtful capacity and the small size of the pipes used.

The knowledge of these objections should call for great caution and more lengthy experience, before the extensive adoption of the system. It has not yet met with general favor in England, where it has been much discussed by eminent engineers.

The growing uneasiness of the public in regard to defective drainage, and the effects of the so-called sewer gas, has led to some important improvements in traps, closets aud such appliances, but more particularly has it been useful, in demanding more skill and care on the part of plumbers and builders.

A method of disposing of street mud and sweepings which has been tried at several places in England, has the promise of success. In the City of Leeds it has been in use during the past year.

It consists of the burning up of the sweepings, in a species of fire brick lined, reverberatory furnaces, with sloping floors, and divided into cells, each cell being capable of destroying seven tons of refuse every twenty-four hours.

The debris forms a kind of clinker, and is removed from the cells every two hours; this is put into mills and there mixed with lime, is ground into mortar, which finds ready sale.

The heat from the furnaces is passed under the boilers, and drives the engine for grinding the mortar, after the sweepings are fully ignited: no additional fuel is required.

The sweepings from the markets and vegetable refuse, is converted into a carbon, useful as manure, and can be readily sold at seven and a half dollars per ton.

It is much to be desired, that Congress should as early as pos-

sible, appoint proper commissioners, with full power to examine and report upon the rapidly increasing pollution of rivers, and thereupon enact such restrictive laws, as will reduce the pollutions to a minimum. Such commissions and laws have been found exceedingly useful in France and England. In the latter particularly, manufacturers have been constrained to reform the most reckless and outrageous pollutions, not only without any disadvantage to their business, but with pecuniary gain: they have led to the establishment of new industries, whereby the source of pollution is actually made profitable to the parties previously vitiating the stream, and to the discovery of methods of utilizing the apparently useless matter formerly thrown into the river.

The citizens of our city should certainly be among the first to urge the attention of Congress to the matter, as but little can be expected from local legislation.

There has not been any considerable increase in the number of new water works, and those built are mostly for the supply of western towns. There are now more than six hundred works in the United States and Canada, of which nearly one-fourth are owned by private companies.

The City of Baltimore is engaged in the construction of extensive works for the introduction of the water from the Great Gunpowder Falls. The design includes a large dam, two large reservoirs and a tunnel of nearly seven miles in length; these works will secure to Baltimore a liberal supply not exceeded by any other in the country.

The manufacture of steel by the Bessemer process, has much increased, particularly in the States of Pennsylvania and Illinois. It is estimated that the product of 1880 has not been less than 850,000 tons, and that a yield of more than one and a quarter millions of tons may be expected during the present year.

An important work of the year, is the substitution of a steel truss for the wooden one on the suspension bridge at Niagara Falls, a work which has been accomplished without, in any way, disturbing the traffic over the bridge.

Of the warnings to engineers by failures, the greatest were the destruction of one span of the St. Charles bridge at St. Louis, and

the Tay bridge in Scotland, where thirteen spans of the bridge and piers were destroyed, and disappeared in the bed of the river.

Investigation by experts shows that this latter structure was not only sadly defective in design, but culpably deficient in material and mechanical construction.

The work upon the Brooklyn suspension bridge has progressed considerably; it is a stupendous work, and is being carried on in the most careful and substantial manner: when finished, it will be one of the great wonders of engineering skill.

The jetties at the mouth of the Mississippi, have realized Capt. Ead's most sanguine expectations, and thus far proved an entire success.

The use of hydraulic cement for ordinary building purposes has much increased, as it should do, its advantages over ordinary mortar being relatively the same, as steel over iron. Much intelligent attention has been directed to the devising and establishing such uniform methods of tests, as will ensure the utmost certainty and most complete reliance upon it.

The application of electric lighting to engineering works has materially increased, and been successfully used in many mines, tunnels and other subterranean works to great advantage, superseding the inconvenient and insufficient portable lights formerly used. Most of the extensive steel works and rolling mills and many of our large factories, where abundance of power is always available, are now lighted by this method. Thus far the "Brush light" appears to have had the most general use in this country.

A marked improvement has been made in the character of brick work and terra cotta ornamentation, whereby the use of that reliable building material for which our city is so celebrated, has been advantageously much extended.

The Smithsonian Museum, and the Government engraving and printing department at Washington, are good examples of such brick work for buildings intended to be as nearly fire proof as possible.

Of local engineering work, the elevated road of the Pennsylvania Railway is the most marked; bringing the terminus of the road into the heart of the city, must prove of the greatest ad-

vantage to it. The work is far advanced toward completion, and is of the most substantial character.

Another local work of the utmost advantage to the city, recently brought to the attention of the Club by one of its members, is the so-called Range System of light houses erected upon the Delaware river. The importance of this to our city from the increased safety and facility afforded in the navigation of the river, has not yet been sufficiently brought to public notice to be fully appreciated.

The reports of the officers of the Club give full details of the work done by it, the number of papers read at its meetings, and the success of the convention called by it at Harrisburg to consider how reform can be effected in the methods of land surveying, with other information, whereby you may judge of the healthy condition of the Club.

It gives me great pleasure to be able to heartily congratulate the members of the Club upon its success and the favorable position it now holds in the opinion, not only of kindred societies in this country, but in Europe, where papers published in its proceedings, have been favorably received, republished entire, or very largely quoted from.

A member of the Club now travelling in Europe, has found his membership to furnish a ready introduction to, and cordial reception from, engineers and public bodies from which he has desired and obtained information.

I sincerely hope that the members will earnestly strive to maintain the high standing the Club has attained, and continue and increase their efforts to furnish materials for its publications, the advantage of a wide spread circulation of the papers they may supply being now assured.

I cannot close without thanking you all for the courtesy paid me during the time I have had the privilege of acting as your President: although now taking leave of you in that capacity, I hope hereafter to have the pleasure and advantage of meeting you frequently.

OPENING ADDRESS

OF STRICKLAND KNEASS, President, on taking the Chair for 1881.

Read January 8th, 1881.

GENTLEMEN:—Before assuming the chair, to which by your favor I have been called, I take great pleasure in expressing my high appreciation of the honor of being thus selected to preside at the deliberations of the Engineers' Club of Philadelphia.

I am well assured of the value of such an association, particularly when composed of and governed by the younger and enthusiastic members of the profession, for, to such must we, whose experience is of the past, look for new devices, designs and expedients, whereby the work of to-day, in the field, on construction, or in the shop, may be performed in the shortest time and in the cheapest and best manner. You have the enthusiasm and ambition of youth to spur you to higher attainments, and the experience and mistakes of the past from which to derive great profit.

The profession of the engineer, as applied to any of the many specialties into which of late years it has been divided, is a *manly* and *honorable* profession, where honesty and integrity are most essential addendas to the scientific education necessary to success, and each member, whether in office, field or shop, is I contend, in the strictest sense of the term, a *producer*.

To the engineers we look for improved highways for traffic or travel, as well as for the best means for transporting thereon with the greatest speed and safety; and in devising and providing the best and cheapest methods for obtaining and carrying to market, the production of the mines and factories, he becomes the trusted auxillary of the capitalist, the manufacturer, the man of commerce and the agriculturist, while the merchants throughout our extended territory, whether in city, town or village, are indebted to him for quick sales with small investment, which by its continued and rapid turn, yields large profit, and, through his efforts, what were once luxuries and enjoyed but by the few, have become necessaries, and are carried to the extreme limit of our

net work of railroads, for the use and enjoyment of all, however humble.

All this I claim to be the result of an improved means of transporting persons and things by railroad or by steamship; and the improvement in machinery, adapted to *them* and to the manufacture of the infinite variety of goods and other machinery that this age of large requirements calls for, has been attained by and through the indomitable energy, perseverance and firm determination of the engineer to overcome difficulties as they present themselves and to supply wants so soon as known and felt.

I know of no reason why the engineers of to-day, should not advance in scientific knowledge, both theoretically and practically, during the coming half century, in the same, if not in a greater degree, than have their predecessors during a similar period. We have, therefore, many wonderful things to suggest, investigate and submit to practical tests, and it is beyond human wisdom to form any idea as to what forces are yet to be brought into subjection, or what—to us seemingly impossible—results are yet to be attained.

Our Club is but an infant in years, only three having elapsed since its organization, but already it has the proportions and actions of developed manhood and is acknowledged as of the fraternity, by its elders. It has grown from a very small membership to a Club of one hundred and twenty-five, with justifiable hopes for increased usefulness and influence, and it is my desire and shall be my earnest endeavour to assist to my utmost in advancing the interests of the Engineers' Club at Philadelphia, while acting as its presiding officer, and to that end I now assume the chair, that the Club may transact such business as may be in order at this time.

VII.

THE PANAMA CANAL AND THE ISTHMUS.

BY COL. JAMES WORRALL, Member of the Club.

Read January 15th, 1881.

THE writer of this paper has only seen the report of M. de Lesseps' statement before a Congressional committee, yet he thinks from that he can convey to Philadelphians some notion of the labor required to effect a thorough cut from Aspinwall to Panama.

M. de Lesseps says that the cut is to be a "one-horse" cut, i. e., wide enough but for the passage of one vessel, as he does not deem it advantageous, in a canal of this size, for vessels to pass each other, except at recesses. M. de Lesseps says he is not an engineer, —if that be his opinion of a canal it is easy to believe the assertion, —so he says that a system of passing places, six miles apart, with inter-communication by telegraph, is better than a canal wide enough for meeting and passing anywhere. Yet he objects to locks, as a cause of delay. If a passing place six miles from another passing place is not as much a cause of delay as a lock, then the common sense reflections of mankind are at fault. To say that stopping at every passing place and telegraphing "Is all clear ahead between recess No. 1 and No. 2?"—or "No. 3 and 4?" as the case may be, is not as bad as a lock for each recess, is to ignore the reflections of common experience. The canal, then, is to be, say 42 miles, or so, long, 66 feet wide on the bottom, which bottom is to be 30 feet below sea level at low tide, and with recesses at every six miles to "hold up" in, supposing a vessel to be approaching another in the next reach.

In addition, there must be at one end, probably at each end, of the canal a tidal lock anyway, for the rises and falls of the tide vary very much as between the Atlantic and the Pacific, and to have the canal open so as to permit the ingress and egress of the tide would simply make it impracticable. People could form an idea of this trouble from the Bay of Fundy, which has a comparatively narrow opening, and at every rise of the tide, unless

the utmost precautions are taken, there is much trouble caused by the rush of water. Seven recesses and two tidal locks are certainly equal to nine locks, and may be equal to eighteen locks, which would about equal the number required for the Nicaragua route, according to one report.

Then it seems the Chagres River is likely to give trouble, and that is to be got rid of by building a dam 120 feet high and, at least a mile long,—perhaps more,—for a dam of that height must be at least that long, to cost $18,000,000.

This, it seems, is to be what is called a catch-water reservoir; a big basin large enough to hold a freshet or two on the Chagres, for Chagres seems to be in the way, and, as it won't run by, like the countryman's stream in Æsop's fable, we must catch it in a basin to keep it from running into our cut and troubling us. M. de Lesseps says a dam of that size will store up one billion cubic yards (metres) of water, which is equal to about one hundred and eighty or ninety billions of gallons, which reads in Arabic numerals, 180,000,000,000—a pretty numerous amount.

Then we know, without M. de Lesseps telling us, that the summit point of the Panama Railroad is 262 feet in elevation above low tide in the ocean, and that being, probably, as low a point as is to be found along the summit, we will take it for the depth of the cut for the canal; but we must add 30 feet for our depth below low water, which brings the depth of Mr. Lesseps cut to 292 feet, and if we add 8 feet for averages (the 292 feet point being the lowest) we shall not be out of the way in calling the greatest cutting 300 feet. The problem then, in its simplicity, is a cut which is 30 feet deep to begin with at the level of the sea, and this carried across a country which is a depression in the chain of the Andes, the highest point of which is 300 feet above our base line or 270 feet above the sea. In this distance we meet a river, the bed of which we must cross by excavating the crossing to a depth of at least 30 feet below the surface of low water in the stream, and deeper than that unless the tide reaches our crossing place.

To get rid of our river we build a dam across it, which holds back its water to the extent of one hundred and eighty billions of gallons, and it is presumed that when the dam is filled there is to

be a weir constructed somewhere along its coast over which the down flowing water of the river, over and above the stored one hundred and eighty billions of gallons, will pass in some other direction to the sea—otherwise there would be no use for the dam—at a cost of $18,000,000. The countryman need not wait; the stream will not run by him. There may be a means calculated on for emptying the basin in the dry season, but this we don't understand yet. M. de Lesseps has only told us of his $18,000,000 dam.

After this water trouble is over the cut goes on, running from 30 feet deep at each end to 300 feet deep in the middle, or at its highest point, and the length of the cut is about 42 miles. The material to be taken out must be some form of granite or other primary or volcanic rock. There may be a good deal of cutting in earth and sand, the detritus of the Andes depression, but the majority of the material is probably primary rock, some of the very many varieties of granite. This is our task in the abstract. Let us try to bring it home to the "business and bosoms" of Philadelphians. There are some Philadelphians who, being entirely and justly satisfied with their position on this earth in that beautiful city, have never left it, and it is for these, and some of their relations who have been away as far as Lancaster, that we now endeavor to describe the de Lesseps canal as if it were to be built nearer home.

Commence, then, at the foot of Market street and dig a pit which shall be 30 feet deeper than low tide and being 66 feet wide on the bottom, the pit will have to be sloped at least as far as the face or line of the houses on each side of the street. Keep on with your pit up Market street, the top always at least as wide as the street from house to house, and at the bottom a canal whose surface is that of low tide in the Delaware and the depth of the water below this surface is 30 feet. At Broad street the depth of the cut would be at least 60 or 80 feet, perhaps more. We don't remember its elevation (about the summit between the two rivers). Well, carry on your cut, still up Market street, until at last you come to the Schuylkill, into which river, as we all know, the tide backs as far even as Fairmount dam. Now across the Schuylkill we must go—only on the Isthmus the Schuylkill is called

Chagres—but across it we must go, and always at our depth, 30 feet below low tide.

How to get rid of the Schuylkill water? We go up stream and at some distance above Fairmount we find the banks approaching each other; so that a dam a little higher than the banks of Fairmount reservoir, costing $18,000,000, will back up one hundred and eighty billion gallons or so of water in a basin equal in area to a lake eight miles long by two miles wide and sixty feet deep. That is what a Yankee might call considerable water, yet it won't exhaust the Schuylkill.

Suppose two feet of water to be running over Fairmount dam, the one hundred and eighty billion gallons would be gone in six or eight weeks, yet the stream would continue to flow on "for ever," as Tennyson says. The Schuylkill rarely reaches even an average flow equal to that, but suppose the one hundred and eighty billions took three months to accumulate and store itself above the dam, it would bother you to get your cut under and across the Schuylkill finished in that time. So above your dam on the Schuylkill you must find some place on the left bank where you can make an extra weir for your incoming water to to flow over, and this you must conduct to the Delaware, for you cannot permit the Schuylkill to run into your pit after you have dug it across. This seems to be the task before Mr. Lesseps by his own description. To spend eighteen millions on a catch-water for the Chagres he must have some such object in view. Well, having crossed the Schuylkill, you go on in a straight line, producing Market street in the form of a Venetian canal street, cutting through everything that comes in your way, meeting several more smaller streams and getting rid of them as best you can. But your business, averaged as has been described, is to cut a ditch 42 miles long, 66 feet wide at the bottom—"across lots"—the deepest cutting being 50 per cent. deeper than Christ Church steeple in Philadelphia is in height. Market street, from the Delaware across Schuylkill, cut down as described, would not more than meet a depth of 300 feet in going from the Delaware to, let us say, Penningtonville or Christiana, on the Pennsylvania R. R., where meeting a branch of the Brandywine or Octorara, supposing tide to back up that far, the cut would be 30 feet below the water in that stream.

To those few good Philadelphians who have been that far "over Schuylkill," the above conveys an idea of what M. de Lesseps proposes, the cut being only wide enough for one vessel. He says it is not even desirable that vessels should be able to pass each other *passing* in such a canal as this; though why we cannot conceive. He therefore has passing recesses at every six miles. He says this thing can be done for a hundred and sixty-eight millions of dollars. Money will do a great deal, but the above is considerable of a job. The Nicaragua route can be built, and a trade capacity of 20,000,000 tons per annum guaranteed, for the odd sixty-eight millions, it is so reputed. Indeed, a canal with locks, by the Panama route, can be done for that or even less. But a thorough cut can be built for money. Yes, but how much? No engineer can estimate it, and it ought not to be commenced unless its projectors can see where they can get $300,000,000. No man who knows what this kind of work is will undertake and guarantee to make a useful canal *a niveau* across the Isthmus for less. As for comparing it with Suez! Ridiculous! The cut behind Chicago, leading Lake Michigan water to the Mississippi, was as difficult as Suez—quite as difficult for its length; only one-fourth its length, however, and not quite so deep, probably not so deep by five feet. The American work was 25 feet deep below water. It is entirely possible that quicksand will be found somewhere between the two oceans. If it be, it will add an indefinite figure to the cost, and may render the cut almost impossible. The Chesapeake and Delaware canal met quicksand, and after that liquid substance had caused the fourteen miles to cost many hundreds of thousands of dollars, the engineers gave in, admitting themselves beaten, and had to lock over the quicksand.

And now the Government is talking about a canal *a niveau* across the Delaware peninsula, which, if quicksand intervenes in any considerable quantity, will be indefinitely postponed.

Indeed it is questionable whether a canal *a niveau* could be cut from the Schuylkill to the Delaware at Philadelphia, quicksand being known to exist in the tongue of land dividing them.

As for Monroe doctrine, and all that, the continent of Europe is not sufficiently interested in this cut, now the Suez is done, to give anybody trouble about it. The international polity to be

consulted on this subject is in reference to the Central American nation, through whose territory the work is to pass, and the United States. The rest do not care enough now and will never care enough about it to go to war. The question is wholly American and can easily be settled.

Since the Suez canal has been cut there is no nation in Europe that would not rather go by that route to the East Indies than take the American Isthmus route, if completed. See map of the world.

The trade to the west coast of South America is the only trade which the American Isthmus route would really benefit in respect to the nations of Europe. Look at it. All the commercial nations of Europe, including Russia, have fronts on the Mediterranean Seas except England, Germany, Holland, Denmark and Sweden. What do they want then of the American Isthmus canal? England says she does not want it because Suez is a shorter route to her, and if this be true in respect to her it is equally so with respect to the Baltic nations mentioned. Whilst, as has been said, all the other nations have fronts on the Mediterranean, and the trade of the west coast of South America is not important enough to cause jealousy between nations, it surely is not of sufficient importance for a *casus belli.* If the Suez route to India suits England then it suits the Baltic nations, and all the rest having fronts on the Mediterranean *must* prefer the Suez route, except as regards the trade mentioned with the west coast of South America. M. de Lesseps will get but a small subsidy from Europe, if she knows herself. He must depend mainly upon this country to build a canal, for this country is more interested than all the other countries put together. What effect his blandishments may have on private capital can not be foreseen.

Now let us look at the routes. For locality, direction, convenience, etc., the Tehuantepec stands first. It is at the point almost exactly where the Isthmus ought to be crossed, provided it was as easy to cross it at one point as at another, or as at any other. Its direction suits best for every trade save that to the west coast of South America, and it is not very much out of the way even for that, if you average the points from which that trade originates on the North American continent.

A vast proportion of the traffic with the United States must

originate in the Mississippi valley, and Tehuantepec suits that better than any other route. The same may be said of the traffic with the Gulf states and the west coast of South America. It is only the states north of Florida who might be expected to prefer the Panama location as an avenue to accommodate that trade. All the rest would be as well accommodated in respect to it, by either the Tehuantepec or the Nicaragua route.

Tehuantepec then is worthy of consideration; but there is against it some 600 feet of elevatiom, which will require, at least, 120 locks, although as an inland water route it is not longer than the Nicaragua, or say 180 miles. The Nicaragua route involves some 130 feet of elevation, or 26 locks, its length being 180 miles, a large part of which is lake navigation. They pretend to say that there is less elevation than the 130 feet, but this involves the necessity of a dredged channel in the lake, which may be set down as impracticable. If you want depth in Nicaragua lake you must add it at the top, not at the bottom.

Think of dredging the Chicago roads to 30 feet, for instance; or the Cleveland, or the Detroit, or the Buffalo roads. It can't be done; the Nicaragua lockage çan't be reduced; it is then at least 130 feet. And now as to Panama. From what has been said a canal *a niveau* is impracticable. You must rise out of the sea on both sides by lockage, incurring at least 60 feet on each side, or say 12 locks. The length of the Panama route then will be, say, 40 to 45 miles, with 12 locks.

But for the East India trade from the Mississippi valley and the Gulf states the Panama route will give you, at the least, 1000 miles of extra ocean distance, saving distance only in the trade with the west coast of South America.

If there is to be but one route made, this ought to throw Panama out, whilst if there is to be but one route, Nicaragua would be the best of the three, as it averages unprofitable sea navigation and saves much lockage, whilst it is not so expensive as Tehuantepec would be, although it might cost a little more than Panama might, with 12 locks.

Other routes have been talked of, but they all have impracticabilities enough to throw them out.

Now then, let us make a rough estimate,—from description

rather than measurement, the canal to be 150 feet wide on bottom so that vessels can always pass each other; turn-outs are clumsy and impracticable.

Tehuantepec.

180 miles of canal at $150,000 per mile,	$27,000,000
120 locks at $500,000 per lock,	60,000,000
Improvements of harbors at both ends, say	5,000,000
Miscellaneous work, reservoirs, weirs, etc., say	10,000,000
	$102,000,000
Contingencies ten per cent.,	10,200,000
	$112,200,000

Nicaragua.—The estimates of the parties interested flutter around $70,000,000, but they had better say $90,000,000 or even $100,000,000.

Panama (raised above sea level).

*10 miles of canal at $500,000 - -	$5,000,000
32 miles of canal at $200,000, - -	6,400,000
12 locks at $500,000, - - -	6,000,000
1 aqueduct over Chagres, - -	10,000,000
Reservoirs, etc., - - -	10,000,000
Harbors, - - - -	5,000,000
Weirs and other works, - -	5,000,000
	$47,400,000
Contingencies, 10 per cent., - -	4,740,000
	$52,140,000

As for a canal *a niveau* it is impossible to estimate its cost. M. de Lesseps estimates it at $168,000,000, which is less than *half* what my estimate would be. If there be quicksand, I would not *try* to estimate its cost.

Now in conclusion, if all things were equal, Tehuantepec stands No. 1; Nicaragua, No. 2; Panama, as above, No. 3; but as they

* This is very low.

are not, I should prefer Nicaragua, leaving Tehuantepec and Panama to take care of themselves; perhaps they would both build in the end. Panama with locks always—say six on each side.

There remains Captain Eads' plan. Ships are built with the expectation of being preserved from disintegration to a great degree by a surrounding pressure from without. Withdraw that pressure, which is equal and universal round the body of the ship, and she bilges, if loaded, in spite of all you can do, especially if you subject her to a jaunt on a rail-way, I don't care how smooth be the rails. My prejudice then against Captain Eads' dry method of taking ships over is simply irresistible, and I drop it as impracticable and not to be estimated. Nine-tenths of the ships lost and never heard of again, are so lost from falling to pieces, as it were; a large portion of their bodies being tossed out of the water, in great storms, whereby the hydraulic pressure is withdrawn from their sides, and they bilge or "hog," as the sailors say.

All of which is respectfully submitted.

VIII.

STRENGTH OF WROUGHT IRON COLUMNS.

By Thomas M. Cleemann, Member of the Club.

Read January 15th, 1881.

A very slight consideration of the proper form of a column to sustain a weight seems to show that the hollow cylinder is the strongest form; and that it will be the stronger with a given quantity of material as the diameter is increased, until it becomes so thin that it fails by "buckling," as distinguished from bending and crushing. Unfortunately, however, it is impossible to "roll" a complete circular wrought iron column, and when this material is used the column is either "built up" of several pieces, or welded. The uncertainty of the strength, and the difficulty of

execution, restrict the latter process to columns of very small size. The pieces which form the larger columns are connected together so as to be as far from the axis as possible, and also so that they shall act as though all of one piece.

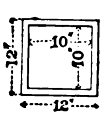
Their strength is usually calculated from the following formula of Rankine (for columns fixed at the ends):

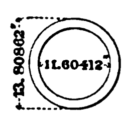
$$P = \frac{f\,S}{1 + a\,\frac{l^2}{r^2}}$$

in which P is the breaking load, S is the cross-section, l is the length, r is the least radius of gyration, and f and a are said to be constants. In applying the formula to experiments on several different ordinary sections used by American manufacturers, these seemed not to be constant, and Mr. C. Shaler Smith discovered values for them when r is expressed in terms of the least diameter, which would suit several sections. These are given in the new edition of Trautwine's "Pocket Book," and tables calculated from them have recently appeared in the "Transactions of the American Society of Civil Engineers."

If, however, we examine the formula critically, we see that f is the limit of the breaking strain per square inch as l decreases to zero. It should then be constant for the same material for all shapes. At first it seems, from Rankine's theoretical deduction, in his "Applied Mechanics," that a should likewise be constant for all shapes, as he assumes. It appears probable, however, that his statement, that the greatest deflection consistent with safety is proportional to the square of the length, and inversely to the square of the least radius of gyration, is not sufficient, but that there should likewise be included the least diameter.

That the term for the least diameter is not included in the least radius of gyration, is shown by the following example:





We have here two sections of the same area (44), and with the same least radius of gyration ($\sqrt{20\frac{1}{3}}$), which would, therefore, have the same strength by the formula, while it is obvious that the

square section is the weaker of the two, having a smaller diameter, a smaller thickness and a weaker shape. In fact, if the columns were 8 feet long, the strength of the circular section would probably be, to that of the square section, about as 4 to 3.

The experiments made for the Cincinnati Southern R. R., detailed in Mr. Lovett's Report, seem to show likewise, in one place, that the strength depends, not only on the least radius of gyration, but also on the least diameter. For, in an experiment on a column of the American Bridge Co., although the square of the least radius of gyration was 8.635 and the column was 10 inches wide in the same direction, yet it broke in the other diameter, which was only 9½ inches, but in which the square of the radius of gyration was 13.51.

By accurately calculating the values of r^2 for such sections as have been experimented upon and published, and which were accessible to the writer, though it is regretted they were so meagre, the value of a has been found to vary considerably; as is shown by the following table. The method of constructing this was as follows:

The least radius of gyration was calculated for each section, and substituted with the other known quantities in Rankine's formula, regarding f and a as unknown quantities. From the several equations of condition thus formed, the most probable values were found by the method of least squares. The results are shown in the table. The values of f do not vary more than was to be expected, on account of the irregularities which always occur in manufactured iron, and it may be considered that Rankine's value of 36,000 is sufficiently accurate. The values of a, however, are seen to differ widely. It should, perhaps, be constant for the same shape, and the writer would have been glad to have found its value for other shapes than those given. It will be regarded as a favor if some of those gentlemen who have broken columns of various sections will transmit an accurate record of the results, with a cross-section on which the dimensions are figured. It is also hoped that sufficient attention has been called to the subject to induce those having the means, to make experiments on various sections. A few judicious experiments on each form—say five or six—would probably be sufficient to determine

a, if it is constant for the same shape. If any member of the
will furnish the data of experiments, the writer will be gla
discuss them. He thinks that a may perhaps be found to be s
function of the least diameter, or of the length divided by
least diameter. If this were the case, a general formula coul
constructed for all shapes, which would be what Rankine's
fesses to be, the constants only varying with the material.
present, however, the experiments on various forms are not s
ciently numerous to decide this.

Other things being equal, that column will be the stronge
which a is least, and this would point to the Phœnix Iron
column as being the strongest form of those noted below. F
f were made equal to 39501 in the first equation of conditio
rived from the experiments, representing the relations betw
f and a for the sections Nos. 5 and 6, a would equal $\frac{1}{45719}$
$\frac{1}{44119}$ respectively, while the table gives its value for the Ph
Iron Co.'s section, No. 4, at $\frac{1}{64698}$.

The last three cases in the table are given merely to satisf
some extent, the curiosity to know the value of a for o
shapes. As only one experiment was recorded in each case,
little importance can be attached to them, and the value of f
to be assumed to obtain a. The one noted in Fairbairn's b
seems to have given way by "buckling," and so does not prop
come within the scope of the formula.

IX.

PROGRESS OF THE SECOND GEOLOGICAL SURVEY O PENNSYLVANIA.

By CHAS. A. ASHBURNER, Member of the Club.

Read January 15th, 1881.

THE Second Geological Survey of Pennsylvania has bee
progress since June, 1874. It is now within three years (mo
less) of its completion. The work has been so extensive, th

	f	a	No. Expts
	39675	[illegible]	21
	36535	[illegible]	32
	40782	[illegible]	5
	39501	[illegible]	5
$\}k)^2\}$	29136	[illegible]	7
	33905	[illegible]	4
	39501	[illegible]	1
	39501	[illegible]	1
	39501	[illegible]	1

sults have been so valuable and numerous, in comparison with the amount of money expended by the State, that a brief summary of the general method of work, together with a statement of some of the results accomplished, may prove of interest to the Engineers' Club of Philadelphia.

In anticipation of further appropriations being made by the State Legislature to continue the work of the Survey, I was requested by Prof. Lesley to address a letter to one of the prominent representatives in the anthracite region, stating the progress of the work. The following contribution to the Transactions of the Club contains in substance the facts to be found in my letter, in the preparation of which I was assisted by Prof. Lesley.

During the six years and a half it has been in progress, forty-two counties have been surveyed in full, eighteen surveyed in part, and only seven remain entirely untouched. During this time twenty-eight county reports have been published, besides sixteen special reports, while thirteen of the former and three of the latter are now in preparation. Of course, as county lines are not often boundaries of geological formations, it has been impossible to adhere to them in all cases. Sometimes a county has been divided, sometimes two or more counties have been united in one report; but as far as possible the descriptions of underground formations have been made to follow familiar surface lines. The work already finished, or nearly so, covers the counties west of the Alleghenies and those on the northern border of the State. The southern border is also completed, with the exception of Bedford and Fulton in the middle, and Delaware and Philadelphia in the east; but the whole of the eastern border and some of the central counties remain unfinished, and the important anthracite region is scarcely touched.

I am informed that the delay in commencing the survey of the anthracite coal fields was due to no want of interest in it on the part of the Board of Commissioners, but to the large extent of country in other parts of the State about which little was known; the thorough manner in which these parts had to be surveyed; the impossibility of keeping more than a certain number of geologists at one time in the field; the difficult, slow and costly instrumental work imperatively called for in certain districts, be-

fore their geological structure could be studied, much less described;—and lastly, the fact that an immense mass of civil and mining engineering work was being done in the anthracite basins which was all promised to the survey as soon as it was got into a condition for geological use.

By this arrangement there has been no loss of time and a great saving of money. The annual appropriations to the Geological Survey have been very moderate ones, and close economy has been necessary to make them suffice.

The field work of the survey begins about the first of May, and the office work about the first of November; and it is with great difficulty that the tasks assigned to the different members of the geological corps are fulfilled. Voluntary aid is of the greatest value and it has been freely tendered and thankfully acknowledged. But the greatest amount of it, and of the best kind, has been bestowed in the shape of notes, maps and sections constructed and compiled by the resident mine owners, superintendents and engineers in the anthracite regions.

The money value of these data to the State is very great, and it would have been a waste of the annual appropriations for the survey to have done such work over again. There were plenty of uses for the money thus saved. Very few people can know how many kinds of work are indispensibly necessary for a great survey, and how carefully and systematically all its work must be prosecuted, if it is to be of any real or permanent value to the Commonwealth. I will give an idea of the general method.

First of all comes the personal survey of each county by a visit to each mine. On the basis of information thus gained the outcropping rocks must be followed, wherever they show themselves, and their topography studied. Base lines must be run, and from these base lines the barometric elevation of hundreds of points must be determined. Thus good geological maps can be obtained, and the belts of out-cropping rocks colored separately. Cross sections are then calculated and drawn, and the thickness of the formations established. From these data it then becomes known how deep beneath the surface at any point any mineral bed lies.

In parts of the State where out-crops along streams are numerous, we can start on this work from the ordinary township and

county maps, which are usually good enough for our purpose. Where the rocks do not show themselves often or satisfactorily, we are obliged to go through the slow and tedious labor of a regular topographical survey, so that the features of the surface may be accurately portrayed on a map of large scale, every ridge indicating some concealed rib of rock; and so by locating accurately every exposure and showing the direction of the strike of the rocks and the strength of their dip, the whole geology of the underground gradually makes itself known.

An anthracite coal land surveyor will comprehend what I mean without further explanation.

This class of work is absolutely necessary in a limestone region containing iron ore deposits. Mr. R. H. Sanders has made a large and very perfect map of the region of the Upper Juniata for forty miles around Hollidaysburg; others, by Mr. Chas. E. Billin, Mr. H. Martyn Chance, and myself, have been constructed in Huntingdon, Mifflin, Center, Clinton and Snyder counties, and several in the bituminous coal region.

One of the most costly and tedious pieces of work of this kind has been the instrumental mapping of the whole of the South Mountain, by Mr. A. E. Lehman, from Dillsburg, in York county, to Monterey and Waynesburg on the Maryland line; but it is only two-thirds done, and will require a year and a half more of field work with a camping party in the woods.

The same party is surveying a limestone and ore belt from the summit of the South Mountain down to Papertown Gap (Mt. Holly Springs) and extending the survey thence along the South Mountain Railroad towards the Susquehanna. The South Mountain has also been studied near Reading, and some valuable results obtained. Some other field work has been done near Reading, as well as a "correctional survey" of the Pocono Mountain mass south of Wiconisco, on the borders of the Lykens-valley coal district.

The whole limestone valley from the Delaware at and above Easton, to the Schuylkill at and above Reading, has been topographically mapped and every iron ore deposit located.

Large maps, showing the dip and strike at every exposure of limestone or slate, have been made by Mr. Sanders, of the whole

of the great valley, embracing parts of Franklin, Cumberland, Dauphin, Lebanon and Berks counties; and it is intended next year, I understand, to continue this work along the slate belt through Lehigh and Northampton counties all the way to the Water Gap.

A similar instrumental map has been made by Mr. E. V. d'Invilliers of nearly all of the mountain country from Reading to Easton; there remains only one year's work to be done to complete this.

Another large map has been made of the region between Norristown, Philadelphia and Trenton.

These maps are not intended for geographical, but for geological purposes. It is impossible in such regions to get any clear and useful knowledge of the underground, except in connection with and under the guidance of the surface features; and these surface features cannot teach anything but error if they are not accurately portrayed. Hence the labor which good geologists bestow on their instrumental, topographical field work.

One of the most valuable results of the season's work is a third report on the oil regions, with maps and illustrations, prepared with infinite pains by Mr. John F. Carll.

A special report, which promises to be of great importance, has been prepared by Mr. Franklin Platt on the subject of the waste in anthracite mining. This report is now going through the press and will be laid before the Legislature at an early day, having been prepared in response to a call by that body for such a report. It will be supplemented by my underground contour line map, showing the topography of the floor of the Mammoth coal bed in the vicinity of Shenandoah and Mahanoy City.

The next great business of the survey has been the analysis of its coals, clays, limestones and ores, and to these should be added analyses of its mineral waters and soils, the latter by Dr. Genth.

The analysis is all the time going on, summer and winter, in the laboratory at Harrisburg, under Mr. A. S. McCreath, and the results are included in the county reports as fast as they are published.

Another necessary part of the business of the survey is conducted in its museum of specimens, rocks, minerals and fossils,

which have to be arranged, labelled, catalogued, and compared with each other; and in the museum, models of difficult pieces of geology in various parts of the State have been constructed and colored, to show the structure beneath the surface, and the arrangement and position of the strata. I need not go further in this brief description of what the Geological Survey has been about since 1874; and I think you will appreciate the magnitude, variety and necessity of its different employments enough, to see that it has a right to be looked upon as a success, having covered more than two-thirds of the State in a satisfactory way, and requiring two years or two years and a half more to finish the remainder. Any citizen of the State can see for himself exactly how much has been done, and how well or ill it has been done, by getting from the office in Harrisburg, or from his Representative or Senator, the volumes of reports of progress already published; all of them illustrated by maps and sections.

The annual report of the Board to the Legislature will be presented at the opening of the session, and will give an exact statement. As to the anthracite survey, it will be very costly and tedious. Underground maps of the worked coal beds must be made on a scale of at least 800 feet to the inch to guide the mining engineer.

Sections must be drawn to show the structure. Some field work will be required *between* such properties as give us materials, because, when we cannot get data from others, we must get them ourselves.

Very little *verbal* description will be published, because the maps and sections are the main things, and will furnish to miners and surveyors exactly what they can use.

It is not *books*, but *atlases* that are required. But there will also be complete figures made of every kind of arrangement and machinery employed in mining and carrying anthracite, so that the miners and engineers of one colliery can see what are the methods employed in all the other collieries.

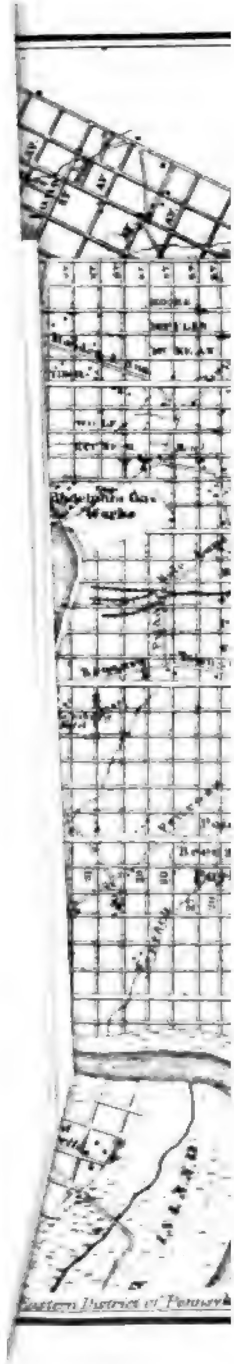
The area included in this season's explorations was about fifteen square miles of the district lying about Wilkesbarre, and about twenty square miles lying in the Mahanoy District, in which Mahanoy City, Shenandoah and Gilberton are located; a

district which contains some of the richest coal land in the world, some of it belonging to the Philadelphia and Reading Coal and Iron Company, some of it to the City of Philadelphia (Girard Estate), and some to private owners. It has a large number of collieries on it, and the first work was to secure maps of the underground workings of these collieries, which, together with the engineers' data, were always cheerfully furnished, and from them to plot a connected map of the district, so far as could be done; the blank spaces to be filled up afterward by the work of the survey. In this way a large amount of valuable material was made immediately available.

Briefly stated, the following are the points, bearing directly on the location of the coal, which the survey undertakes to determine:

1. The outcrop of the coal beds.
2. The area of surface underlaid by each bed.
3. The dip and strike of each bed where worked.
4. Area worked out.
5. Area opened but not worked out.
6. Area undeveloped.
7. The most probable structure of the undeveloped portions of the coal beds lying between these already developed, including the dip, strike, depth of basins, etc.
8. These points ascertained, it is possible to estimate closely the amount of coal available for mining at different depths, which is a problem of constantly increasing importance.

To prepare all these data for publication will certainly require two years of hard work, summer and winter, with a large corps of assistants. Meantime other parts of Western, Northern, Middle and Southeastern Pennsylvania, not yet wholly surveyed, will be finished.



X.

INTERCOMMUNICATIONS IN CITIES, ETC.

BY PROF. L. M. HAUPT, Member of the Club.

Read January 15th, 1881.

PART I.

IT is one of the duties and privileges of engineering societies, knowing the possibilities of their profession, to consider and suggest plans and projects which tend to ameliorate the condition of the communities in which they are located. To this end we have already discussed and published valuable papers upon the subject of the FUTURE WATER SUPPLY AND SEWERAGE OF PHILADELPHIA, by Messrs. Darrach and Hering. It is equally important that something should be said upon the subject of increasing the facilities by which men and merchandise may be moved in any desired direction through cities, and the enormous amount of time and energy now wasted in passing from place to place be saved. Our president has already pointedly referred to this important matter, in his recent inaugural address.

The elements which enter into the discussion of this question are *time*, *space* and *power*, and it may be assumed that, at least for business purposes, the time consumed in transit between two places is practically wasted. The less the time spent, therefore, in traversing any given space, the greater will be the gain to the individual, and hence to the community. This saving of time may be accomplished in either or both of two ways, namely, by lessening the distance or increasing the velocity. The former is certainly the better since it diminishes the time as well as the work required of the man, beast, vehicle or machine moving over the given space. The latter method is only desirable when advantage may be taken of some cheaper and more rapid motor than the one in use, passing over the whole or a portion of the distance proposed to be traversed.

The most perfect solution of this problem attainable is that in which both of these methods are combined to produce the desired

result, that is, the ways of communication should be made as direct as possible, and the facilities for traversing them be increased to the greatest extent.

The question of greatest moment to the profession at present is, "How may we provide the ways and means for a cheap, reliable and rapid transportation?" and its answer must be determined by a consideration of the general or particular conditions entering into the given case—as to nature and amount of traffic, topography of country, means of conveyance, motive power employed, etc., etc. It is in the solution of these subordinate questions that all the subdivisions of the profession are brought into play, but I propose to apply the general question only to the consideration of some of our local requirements.

First then, how may we provide the ways and means for cheap, reliable and rapid transportation? Evidently, by making the route as direct as possible, and by using the most economical motors obtainable consistent with the desired velocity of transit. To secure this result involves a consideration of the *resistances* which interrupt or impede travel and which may be included in the obstructions offered by topographical or other features of the earth's surface and by atmospheric and mechanical resistances.

It is the business of the engineer to reduce these resistances to a minimum by any available means and at a cost, the interest of which shall not exceed the revenue from the proposed improvement. It is in the consideration of these prospective values that the element of uncertainty chiefly lies and in which the expediency of the enterprise is involved, and although, strictly speaking, it is not an engineering question, yet it is so closely related to the success of any project that it cannot be ignored. In the following discussion the values used and quantities considered will be taken from the latest and most reliable statistics obtainable.

To apply these principles to any particular case it becomes necessary first to determine what are the existing modes of transit; second, to devise such improvements as will remove or reduce these resistances to the lowest limit at a reasonable cost; and third, to propose such means as will inflict the least amount of damage and confer the greatest amount of benefit upon the community.

Applications.

Now, in the City of Philadelphia, the ordinary ways of communication are: 1. By avenues and streets. 2. By railroads. 3. By rivers; all of which are related to each other and fulfil their requirements more or less perfectly according to circumstances.

The Street System.

As the streets are the principal means of communication it is important that they should be so planned and distributed that they may best serve the purposes for which they were intended, viz., traffic, travel, residence, health and defense.

The daily wants and occupation of the citizen and those who may be dependant upon him make it necessary that he should have every facility for locomotion, and hence an ideal system of streets would be that in which they extended from every point to every other point; this would reduce the city to an uninhabitable plain, or one in which the inhabitants lived under the surface used for travel; the other extreme is that in which the total area of the city is devoted to buildings with no public ways of communication.

It is evident, therefore, that there must be a compromise affected, and that a definite relation must exist between the areas devoted to public and to private purposes, or to streets and to buildings. What this relation should be, it is the duty of the projectors of a city so far as possible to determine. It differs in almost every city in this country; in some, the streets being too broad and numerous, in others, too narrow and far apart.*

*For a more complete discussion of this relation, the reader is referred to a paper on "The Best Arrangement of City Streets," published in *The Franklin Institute Journal*, No. 616, April, 1877, in which it is shown that the percentage of street to building area may be expressed by the formula $\left(\frac{2lw + w^2}{l^2}\right)100$, in which l represents the length of one side of a square of any size, and w the width of the street bordering two sides of it.

The opening of two diagonal avenues, say 100 feet wide, as hereafter proposed, would consume $1\frac{1}{4}$ per cent. of the building area of the large square o. which they are the diagonals, hence the population disturbed would vary in the same ratio or $1\frac{1}{4}$, whilst the building lines would be increased by over 7 per cent. So that instead of driving out the populace, it would enable more to settle in the very heart of the city.

For foot passengers the ways should be frequent, but comparatively narrow. In this respect Boston surpasses most American cities for there, business is concentrated, and the "cut offs" are very frequent to those thoroughly familiar with the ins and outs of the "hub." Our city plan could be much improved by opening diagonal ways for pedestrians through the blocks similar in their general features to that at "Walnut Place," and thus rendering a much larger amount of the building area available for stores and offices. At present many of the blocks are simply "hollow squares." By opening or enlarging streets through them, the available building area would be largely increased without at the same time crowding out any of the population.

THE RECTANGULAR SYSTEM OF STREETS is good enough so far as it goes, but for a person whose objective points are on the diagonal lines of this system, it is the worst possible. Every such individual must lose 42 per cent. of his time, distance and energy in traveling between the termini of his route. It is the same whether he ride or walk, except that in the former case the wear and tear comes on the horses and vehicle instead of on himself, and the cost to the car company transporting him is increased in the same ratio. This waste when taken collectively amounts to a very large quantity and is, to that extent, a bar to the growth of the city.

It is evident that the value of an article to a purchaser is largely influenced by the time, distance and trouble necessary to be expended in procuring it, and that beyond certain narrow limits it will not pay to go for articles of little worth; thus new centres of trade are established at the expense of the old ones. It is also self-evident that the amount of traffic is a function of the population. If the latter, therefore, does not increase neither will the local business of the city. Now, it is a very significant fact that during the past decade the population of that portion of Philadelphia bounded by Washington Avenue, Passyunk Road and Wharton Street on the south; by the Delaware on the east; the Schuylkill on the west, and by Poplar, Sixth and Oxford Streets and Frankford Road on the north, which I shall designate as the *heart of the city*, has *decreased* in population 19,466, whilst in the remaining seventeen wards the population has *increased*

195,690. Two of the wards within the above-named limits, have increased slightly; the Tenth by 51, and the Fifteenth, which is on the border, by 3,115. (See Census of 1880).

The net increase outside of the district mentioned was 195,690, whilst its gross population was 513,772, the remaining 332,208 residing within those limits.

Now, assuming the centre of the retail trade to be at Eighth and Market; that of the commercial and monetary interests to be at Fourth and Chestnut; and that of municipal business to be at Broad and Market, it is evident that a large portion of the population living beyond the limits mentioned, is obliged to travel a long distance out of the way to reach these points, and that if the merchants, bankers and professional men generally desire to retain the patronage of this vast population, which is daily getting farther away, it will be necessary to increase the facilities of communication by opening diagonal streets, providing more rapid means of transit, or moving their stores, banks and offices, out in the wake of the receding population.

Proposed Improvements.

Of these three methods, the first seems certainly the best for all parties concerned. The opening of an avenue from Gray's Ferry Road to the corner of Brown and Laurel, and another from Twenty-first and Pennsylvania Avenue to Front and Washington Avenue, wide enough for at least two lines of street cars, four or six of carriage-ways with twenty feet sidewalks, well shaded with trees, but having no projecting steps or bulk windows, would constitute one of the grandest improvements this city has ever devised. It would reduce the distance from 23,000 to 16,000 feet, thus saving 1⅓ miles for every person required to move diagonally across the heart of the city, with the same percentage of saving for any part of the distance. It would open up over twelve miles of building lines available for stores and dwellings, and as these avenues would be crowded thoroughfares, they would form the most desirable sites for trade in the city. The additional building fronts thus created would far more than accommodate the small portion of the inhabitants displaced by such an improvement.* It would open a direct line of communication to

* See foot note page 117.

the Park from the southeastern portion of the city, and furnish avenues for the more efficient performance of all municipal duties such as may arise from fires, riots, etc. These improvements would involve some changes in the railroads which will be discussed hereafter under that head.

Distribution of Population.

It will be interesting to note whilst on the subject the distribution of our vast population, the changes that have taken place during the past decade in the several wards of the city. The following table is arranged by wards in the order of the density of their populations, computed from the areas furnished by the City Engineer, Mr. Samuel L. Smedley and from the census returns for 1880.

The numbers in the first column indicate the order of succession of the wards arranged according to density of population; those in the second, the numbers of the wards; the third, the areas of these wards in acres; the fourth, the population in each ward in 1880; the fifth, the increase or decrease in ten years, and the sixth, the number of square feet per individual.

DISTRIBUTION AND DENSITY OF POPULATION IN PHILADELPHIA, 1880.

ORDER OF DENSITY.	WARDS NOS.	AREAS IN ACRES.	POPULATION 1880.	INCREASE + DECREASE —	AREA PER CAPITA IN SQ. FT.	REMARKS.
1	3	122	18,271	— 878	291	Most dense.
2	14	152	22,354	— 289	297	
3	4	147	18,853	— 1,999	340	
4	17	161	20 451	— 896	343	
5	12	124	14 690	— 481	368	
6	13	164	18,646	— 1,310	383	
7	7	281	31,087	— 471	393	
8	10	230	23,363	+ 51	430	
9	2	283	28,498	— 1,722	436	
10	16	180	17,892	— 1,454	440	
11	19	447	43 887		444	And 31st inc. 29,955.
12	11	135	12,930	— 1,915	452	
13	20	469	43,207		466	And 29th inc 27,352.
14	30	332	29,100		497	And 26th inc. 27,635.
15	5	206	16,368	— 2,368	548	
16	15	671	47,865	+ 3,215	611	
17	18	4 6	29,354	+ 2,988	617	
18	8	279	19,545	— 2,745	624	
19	31	456	31,308		634	
20	9	256	12,481	— 4,146	895	
21	6	206	10,064	— 2,064	897	
22	29	900	40,787		961	Combined with 20.
23	21	4,560	19,699	+ 5,835	1,008	Manayunk.
24	1	3,526	43,085	+ 17,268	3,600	
25	28	4,060	34,442	+ 24,072	5,135	
26	26	4,768	35,138		5,914	Combined with 30.
27	24	6,224	46,057	+ 21,125	7,500	West Phila., N. of Market.
28	25	6,630	36,104	+ 17,465	7,900	
29	27	7,475	23,284	+ 3,899	13,900	" S. "
30	22	11,593	31,798	+ 9,193	15,944	Gtn. & Chest. Hill.
31	23	27,339	26,522	+ 5,634	45,000	Along Del. R. ab. Tacony Creek.
			846,980	+ 195,690		

NOTE.—Where new wards have been formed from old, the statistics are combined for comparison.

An analysis of the above table reveals the fact that the areas of densest population form two zones or bands; the one on the south of the city extending from Pine to Christian Streets, and that on the north from Vine to Poplar, especially east of Broad, and extending around to the northeast through Kensington. The middle zone, or that from Pine to Vine Streets, including part of the Seventh, the Eighth, Ninth and Tenth Wards, is not so densely settled; the area per capita ranging from 430 to 900 square feet.

It will be observed that throughout these three zones the population has decreased by nearly 20,000, whilst the increase beyond these limits amounts to nearly 200,000, distributed in the following directions: South of Wharton Street, or on "the neck" about 17,000 in the First Ward, and about 27,635 in the Twenty-sixth and Thirtieth Wards; total, 44,635, or nearly 50,000 in ten years, due doubtless to low rents, extension of street car lines and erection of numerous improvements, as grain elevators, oil refineries, etc. The total population is 107,323. West of the Schuylkill river lie the Twenty-fourth and Twenty-seventh Wards separated by Market street. The former, including the Park and Centennial Grounds, increased 21,125; the latter, including the Almshouse property, Woodland Cemetery, etc., 3,899; total, 25,024. The great difference being due to the impulse given by the Centennial and by the greater railroad facilities enjoyed by the Twenty-fourth over the Twenty-seventh Ward.

West Philadelphia is well provided with divergent lines of communication, leaving nothing to be desired in that part of the city at present. There are Woodland, Baltimore, Lancaster and Belmont Avenues. Market Street and Haverford Road enabling its populace of 69,341 to reach the Chestnut and Market Streets and Fairmount Avenue bridges by the most direct routes possible.

The northern section of the city beyond Poplar Street, including the Nineteenth, Twentieth, Twenty-eighth, Twenty-ninth and Thirty-first Wards, has a total population of 193,631, being an increase of 81,379, or nearly 45 per cent. in ten years.

The Twenty-first Ward, embracing Manayunk and Roxborough, has increased but slightly, and the Twenty-second Ward, containing Germantown and Norristown, about in the same ratio. In the

Twenty-third Ward the population is so sparse that there is more than an acre of land to the individual—but it is as yet very remote, and the means of communication are imperfect.

There are in all 302,666 persons living north of Poplar Street, Sixth and Girard Avenue; 107,000 south of Washington Avenue, and 70,000 in West Philadelphia, making a grand total of nearly 500,000; a large percentage of whom may be obliged to cross the heart of the city daily in oblique directions. Is it not of some moment then that additional facilities should be offered them?

The four avenues proposed would lead up to the very doors of the Public Buildings, and would also connect directly with the Elevated road on Filbert Street.

For the better accommodation of the residents of Kensington, Bridesburg, Frankford and West Philadelphia, a desirable improvement would be the extension of Kensington Avenue through to Francis Street, and thence on to Fairmount Avenue near the bridge. Thus saving, as before, about 1⅓ miles to all persons obliged to cross the city in that direction.

Street Car Travel.

From the last annual reports of six out of the twelve passenger railway companies in the city, it appears that the

Union Line carried . . .	20,053,880	passengers.
The Frankford and Southwark,	8,103,291	"
" Ridge Avenue, . . .	5,023,861	"
" Philada. (Chest. and Walnut),	9,440,591	"
" Hestonville and Mantua,	4,828,314	"
" Green and Coates, . .	3,405,350	"
Total of these six roads,	50,855,280	"

If the remaining six companies have done as well, it will make a grand total of over *one hundred millions* of people who have ridden in the street cars of this city during the past year.

The expenses of these roads aggregate $1,990,088.56, making the cost per passenger only two cents; now assuming that the average distance traveled by each person in the cars to be four miles, the cost per mile per individual would be five mills.

If then, by any means, the distance traveled over by this vast moving population could be lessened but one mile, it would effect a saving to the companies of a half million of dollars, and to the passengers, of whom a large proportion constitute the bone and sinew of this manufacturing centre, of one and a half millions per annum.

This is only the direct *pecuniary* advantage, but the economy of time and labor must also be considered.

The pedestrians will probably outnumber the street-car passengers ten-fold, but as a basis of calculation let us assume them equal, and take the rate per mile of a good walker at fifteen minutes, then the saving of one mile of distance would result in an economy of 25,000,000 hours, or 2,852 years for pedestrians only, and as the average velocity of a street-car is about double that of a man, the saving would be only one-half this amount or 1,426 years, making a total of at least 4,278 years gained in time by saving one mile of distance to the rambling population of Philadelphia. We do not pretend to convert this into dollars and cents as the unit of comparison is too variable. The amount of kinetic energy which might be saved by reducing distances to the extent of only one mile, may be readily computed by multiplying the number of foot-pounds which a man of average weight, say 144 pounds, expends in traversing this distance, by the number of pedestrians.

"A man walking 23 miles on a horizontal road does as much work as if he lifted his body up a vertical ladder through a height of one mile. Hence, in walking one mile he must raise himself 230 feet," performing an amount of work represented by 33,120 foot-pounds, or say $\frac{1}{15}$ of a horse-power per individual, and for the 100,000,000 of our nomadic population there would be an economy of 6,666,666 horse-powers.

Thus it will be seen that these elements which may appear too insignificant to the individual to merit a moment's consideration become in the aggregate important factors in the welfare of the community, for

"Many a little makes a mickle,"

and if the annual saving to the entire population from any improvements amounts to millions of dollars, as it does in this case,

then it will pay to invest many more millions in its accomplishment.

It should be observed also that these results are obtained from a consideration of the movement of *persons* only, and do *not* include the immense amount of merchandise, or the large number of animals and vehicles constantly handled and used in the ordinary routine of business.

Opposition to such a scheme must of course be expected as a natural result attending every improvement. Our local history is full of instances, for example, passenger railways were introduced January, 1858, yet "there was much opposition. Pamphlets were published, and some large owners of property threatened to sell out and move away from the route."* Many other cases might be cited were it necessary.

The public seem now content to accept the situation and welcome the system of railways as an indispensable convenience, which has not only enhanced the value of their property, but has been the means of otherwise enriching them both directly and indirectly. The same consequences will follow any system which increases the facilities of communication.

If it be asked why improvements of this nature. if so important and necessary, have never been suggested, or at least urged before, it must be answered that they are of such a character that no corporations could expect any direct return for money invested in opening streets over which they could have no control, and upon which they could collect no tolls, and that the private citizen, however much he might wish such conveniences, would be apt to consider his individual petition impotent to produce the desired result. Moreover, it is only in consequence of the rapid growth of the city that the necessity now exists, and is becoming every year more urgent. The present magnitude of this city of homes was not anticipated by its founders, or doubtless provision would have been made in the original plan to meet this very demand, but the longer it is delayed, the more difficult it becomes. A beginning should at least be made on one of the shorter lines as that from Broad and Market to Pennsylvania Avenue, provided

*Watson's Annals.

arrangement can be made to remove the Railroad tracks from the latter avenue, as suggested in the second part of this paper.

PART II.—RAILROADS.

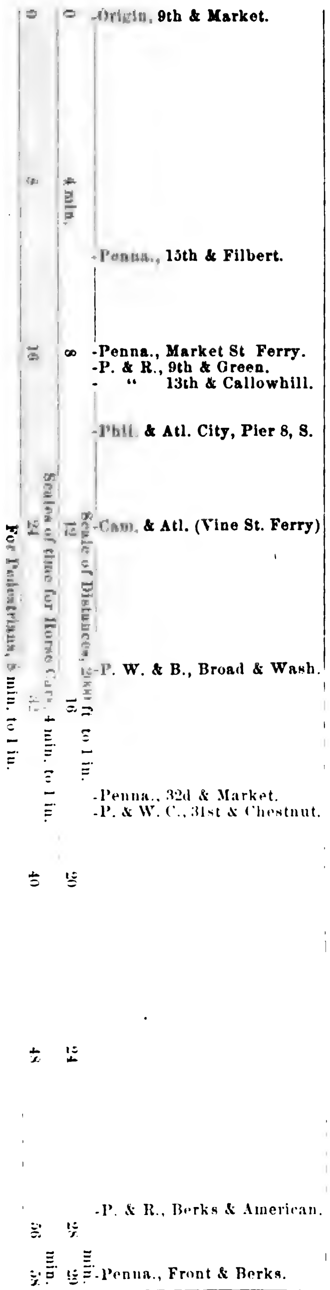
In my first paper on this subject, read before the Club, the discussion was limited to the street system, the amount of travel through it, the distribution and growth of population and the necessity for additional avenues in certain directions, with a computation of the value of one mile of distance saved. I now propose to extend the subject under consideration, so as to include the railroads in and around the city, with reference to their location, local traffic and terminal facilities, and to make some suggestions as to certain changes which I believe would constitute valuable improvements which will be required in the not very remote future.

Location.

Under this head I propose to consider the position of the lines of railroad, with reference to the directions and grades of streets. To this end it will be necessary to establish some limit for the local movement, and some centre which may fairly be considered a *point d'appui* for the suburban population. For this latter reference we may take the New Post Office at Ninth and Market Streets, as being sufficiently central, and for the former, a circle of ten miles radius, described from the point just selected.

A detailed verbal description of the location of the roads leading out of the city need not be given, as a glance at the accompanying map will supply all the information desired as to direction; it is only necessary to state that all of the lines, with one exception, are surface roads intersecting the streets and other railroads generally at grade.

They are the Penna. R. R., with its leased lines and branches, embracing the United R. R's of N. J., the West Jersey, Camden & Amboy, Camden & Burlington County, the Connecting Railroad and the Delaware Division; the Phila. & Reading, with its leased lines and branches, embracing the Delaware & Bound Brook, North Penn., Phila., Gtn. & Norristown, the Junction Railroad, and the Richmond & Chester Branches; the Phila.,



Wilmington & Baltimore, with its leased line;* the Philad'a & West Chester, the Camden & Atlantic, the Phila. & Atlantic City (narrow gauge) all in operation, and the Phila. & Chester Co. R. R. proposed.

To compare the facilities offered by these lines to the people in and around Philadelphia, it is necessary to note the distances from their termini to the assumed centre of business, and the time consumed in reaching it either on foot or by horse cars. These results may be most intelligently exhibited by a diagram in which distances may be plotted as abscissa and time as ordinates, using two time curves, one for pedestrians, the other for street car passengers, but since the time consumed varies directly as the distance traveled over, these curves will be represented by right lines, the scales of which are proportional to the velocities of travel. In the formula $s = v\ t$, which is the equation of a right line, by substituting for s the space represented by one unit of the distance scale, and for v the velocity per minute we obtain the time scales, which in the subjoined diagram will then be $2000 = 500$ t for street cars, and $2000 = 250$ t for pedestrians, or 1 inch = the space passed over in four minutes in the former case and in eight minutes in the latter.

These results are also appended in tabular form.

* *Purchased* by the Penna. R. R., March, 1881.

TABLE I.—SHOWING RELATIVE DISTANCES OF THE R. R. DEPOTS IN PHILADELPHIA, FROM NINTH AND MARKET STREETS, WITH THE TIMES REQUIRED TO TRAVERSE THEM EITHER ON FOOT OR BY HORSE CARS.

NAME OF COMPANY.	DISTANCE IN FEET.	TIME IN MINUTES BY PEDESTRIANS.	HORSE CARS.
1. Penna. R. R.—New Terminus (15th and Filbert)	2,871	11	5.5
2. " West Jersey, (Market St. Ferry)	4,010	16	8.0
3. Phila. & Rd'g, (9th & Green), P. G. & N. C. H. & B. B.	4,279	17	8.5
4. P. & R. E. R., (13th and Callowhill)	4,531	18	9.0
5. Phila. & Atl. City, (Pier 8, South)	5,050	20	10.0
6. Camden & Atl., (Vine St. Ferry)	6,188	24	12.0
7. P. W. & B., (Broad and Washington Ave)	7,676	30	15.0
8. Penna., (32d and Market)	9,043	36	18.0
9. Ph. & West Chester (31st and Chestnut)	9,000	36	18.0
10. Phila. & Read., (Berks and American)	13,871	55	27.5
11. Penna., (Front and Berks)	14,571	58	29.0

The time in the above columns is computed from the observed and recorded average rates for street cars propelled by horses, which is found to be very nearly 500 ft. per minute, or 5.7 miles per hour. The rate for pedestrians is taken at one half that, or 250 ft. per minute, 2.9 miles per hour.

The average running time of the accommodation trains, including stops at intervals of one mile, is about three (3) minutes per mile, so that to reach the perimeter of the 10 mile district would require 30 minutes to be added to the time consumed *en route* to the depots.

Thus the running time from Bryn Mawr to Thirty-second and Market, present terminus of P. R. R., 9.4 miles, averages 27 minutes. To walk thence to Ninth and Market requires 36 minutes more, or to ride, without delay in starting, 18 minutes, making the entire time 63 or 45 minutes. Hence it appears that a person living ten miles from the city must devote daily at least 1½ hours if he ride, or 2 hours if he walk, in making the round trip. For two or more trips the time so absorbed is proportionally increased. The enterprising company, whose road is referred to in the above instance, realizing the value of this enormous loss, when taken collectively, to its patrons and of the importance of bringing the home and the office nearer together in point of time, are investing millions of money in constructing an elevated iron and brick viaduct from Thirty-second and Powelton Avenue into the very heart of the city, and by this means propose to reduce the time between the limits previously cited as follows: From Bryn Mawr to Broad Street, probably 30 minutes; from thence to Ninth and

Market, 11 minutes, or 5.5; but assuming that all would walk these five squares, it would make the total time 41 minutes as compared with 63.

For that portion of the route between the proposed and present sites of the terminus, the minimum saving would be 10 minutes, or 20 minutes on the round trip.

The effect of this improvement has already made itself manifest in enhancing the value of suburban property along the line of the road, from which the company will derive a direct benefit as well as from the increased amount of local travel, which must necessarily follow in its wake. It is also proposed to construct a branch from Hestonville around the western boundary of the Park, to connect with the projected gravity road at Belmont and to open up one of the most magnificent and commanding sections of the city for suburban villas on the highlands near Academyville.

Another line is projected down the west banks of the Schuylkill to tap the refineries below Eastwick's Park, and thus provide additional facilities for one of Philadelphia's largest industries, and still another to Chestnut Hill, conditioned upon the right of way being furnished by residents of that section.

Local Traffic.

To obtain some data with reference to the nature and amount of this traffic, I have written to the officers of the several companies, whose roads terminate in the city, asking for information as to the number of grade crossings within city limits, the number of trains of all classes arriving at and departing from their various depots daily, and the number of passengers carried to and from stations within ten (10) miles of their termini. The answers, so far as received, have been arranged in tabular form for convenience of comparison, and will be found interesting as revealing the magnitude of the daily local movement within the narrow limits selected, as well as the general perfection of the management, as regards safety and rapidity of motion.

TABLE II.—Statistics of City and Suburban R. R. Traffic.

(WITHIN 10 MILES OF DEPOTS; FOR YEAR 1880.)

NAME OF LINE.	NO. OF GRADE CROSSINGS.	AV. NO. DAILY TRAINS. PAS.	FT.	TOTAL.	NO. OF TRAIN CROSSINGS.	NO. OF PASSENGERS WITHIN 10 MILES, ANNUALLY.	DAILY AVERAGE.	REMARKS.
PENNSYLVANIA R. R. (*a*)								(*a*) Data furnished by the Company.
Main Line, (32d and Market)	1	62	102	164	164	457,953	1,255	To Bryn Mawr.
Delaware Extension	35	3	100	103	3,605			To Point Breeze, Girard Point, Greenwich and Delaware Ave.
N. Y. Div., (connecting R. R.)	26	56	48	104	2,704 }	506,059	1,389	
Kensington	37	26	15	41	1,517 }			
Amboy Div., C. & A. }	35	28 }	12	62		581,091	1,600	In N. J. not included in train crossings.
Cam. & Burlington Co. }		22 }						
West Jersey, in N. J.		25	No report	25		157,983	982	Train crossings not in City, say 5000.
Total, P. R. R.	99	222	277	499	7,990	1,703,986	4,866	
PHILA. & READING.								
9th & Green, Norristown Br.	53			44	2,332			From 9th and Green to 16th St. Junction, there are 20 grade crossings, over which there are 175 daily trains, making 4000 train-crossings on this portion of the line.
" Gtn. & Ch. Hill Br.	52			75	3,900			
" Bethlehem Br.	36			16	576			
" N. Y. Branch	36			20	720			
3d & Berks, Bethlehem Br.	16			47	752			
" N. Y. Branch	16			31	496			
13th & Callowhill, Main Line	16			40	640			
Richmond Branch	23			64	1,472			(*b*) From Broad St. around to Berks, via Front and Willow.
Willow & Noble St. Wharf.	44 *b*			26	1,144			(*c*) These crossings were counted up on the Maps in the Registry Bureau of the City.
Total, P. & R. R. R.	292 *c*			365	12,032	5,518,065	15,116	
PHILA., WIL. & BALT.	35	54	*d.*	54	1,890	861,664	1,000	Approximately (*d*) not reported.
PHILA. & WEST CHESTER	12	13	2	15	180	450,000	1,232	As far as Media, 12.67 miles.
CAMDEN & ATLANTIC, N. J.	36			20	720	250,000*		* Rough estimates and averages, not included in totals.
PHILA. & ATLANTIC CITY, N. J.		6	2			100,000		The total number of annual passengers does not include those on the Camden & Atlantic, nor the Phila. & Atl. City.
	438			931	21,992	8,033,715		

From this table it will be seen that there are 99 grade crossings within city limits on the P. R. R.; 292 on the P. & R. R. R.; 35 on the P., W. & B. R. R., and 12 on the P. & W. C. R. R., making a total of about 450. This includes only those streets and railroads, which are opened for travel and hence are dangerous intersections. The rapid extension of the city streets will largely increase the number in the next decade.

On the above-named roads and their branches it will be seen that there are a large number of daily trains (both ways) passing these numerous crossings. To determine as nearly as possible the aggregates, I have multiplied the number of crossings on any branch by the number of trains on that branch, and thus obtained the equivalent number of trains passing any one crossing. These products I have called *train-crossings*, as the analogue of the term "foot-pounds." The footing to this column shows the total number of trains passing any one crossing per day, which is about 22,000, and this is exclusive of "shifters" and some freight trains not reported. If 18 hours be assumed as the length of the day for railroad operations, these 22,000 train-crossings must be made at the rate of about 20 per minute, or in other words, there must be a train upon twenty crossings every minute of the day, hence the obstruction to street travel can readily be imagined. As to danger, the wonder is, not that there is an occasional life or limb sacrificed, but that the casualties are not far more frequent.

It becomes us then to inquire where this obstruction is greatest and how it can be removed.

Of the 7580 crossings by trains on the P. R. R. nearly one half are on the Delaware extension, and of the 35 street crossings on that division but 18 are found between Thirty-second and Market and Greenwich Point, a distance of about 7 miles, the remaining 17 are along the Delaware front up to Dock Street. Nearly all being in sparsely settled districts with very little street or road travel.

Of the 26 on the Connecting R. R. there are but 9 between the depot and Frankford Junction, and of the 37 on the Kensington branch 20 are south of the junction. As will be seen therefore, these do not interfere seriously with travel.

Running on down the list, we see from the column of remarks that there are 155 trains from Ninth and Green Streets to the junction at Sixteenth Street, which pass over 26 grade crossings, giving an aggregate of 4030 train-crossings on this branch alone, and that in a portion of the city where the travel is frequent, thus causing numerous interruptions. This is a point then that will need further special attention, for it does not become us to suggest an evil without providing a remedy.

On the Richmond branch there are 1472 train-crossings, from the Berks Street depot out, at least 1248 more, and on Willow Street, etc., 1144, all of which are in thickly settled parts of the city. The existence of these grade crossings is a source of continual delay, danger and expense, and therefore the following plan is suggested for their removal.

Proposed Improvements.

Philadelphia and Reading System.—It will be seen by an examination of the map that the locations of some of the branches of this road are very circuitous. The Richmond branch makes a détour to the north of over a mile, by which grade is reduced at the expense of 4000 ft. of distance. Still there is an ascending grade on that portion of the road, requiring auxiliary power. This was undoubtedly a good location, when the traffic was light and property of little value; but now that the tonnage has increased to 4,364,995 net tons per annum, and that the city is rapidly covering the site of the road, increasing the number of crossings and delays to travel, it seems that the interest of all parties requires a tunnel, to be built from the Falls bridge under Allegheny Avenue to connect with the present location at or near Sixth Street. By this means the distance would be reduced from 19,000 to 15,000 ft., the use of auxiliary power be dispensed with, as the grade could be made slightly descending, fifty-four (54) street crossings either at grade or by bridges would be saved, and it is believed that the annual saving on the transportation with the value of the property surrendered would more than pay for the tunnel. If it cost four (4) mills per ton per mile for coal, up grade, and six (6) mills for merchandise,—the actual cost to the company for the transportation of the freight of last year

over the present elbow must have been about $100,000,—whilst by the tunnel on a *descending* grade it would be reduced to a little more than $50,000; hence $1,000,000 @ 5 per cent. might be judiciously invested in the construction of the tunnel, which ought be built for that amount.

This being done, *all* the freight on the main line could be brought in via the Richmond and North Penn'a branches to the depot at Front and Willow Streets without increasing the distance to that point, thus leaving only the passenger traffic on Pennsylvania Avenue, but this, if there were room for it, could just as readily be transferred to the depot at Ninth and Green Streets, in which case that portion of Pennsylvania Avenue from Twenty-first Street all the way to the Columbia bridge could be turned into a grand avenue, the continuation of one of the diagonals suggested in the first part of this paper, forming the most direct connection between the city and the Park.

This plan, it will be observed, is contingent upon increased accommodations at Ninth and Green. Let us see if it be possible to effect them. There are already 155 daily trains to and from that depot, while from the Broad Street depot there are but 14 passenger trains. The increase, therefore, would be but a small percentage of the present amount of travel, and could probably be provided for, but as there are already too many dangerous crossings on this line (the number of train-crossings being over 4,000 per diem,) I should heartily recommend elevating the tracks from beyond Broad Street all the way down, and consolidating the depots at Thirteenth and Callowhill and Ninth and Green in a new one at Ninth and Callowhill, where there seem to be some strong inducements for its location. From Spring Garden Street north, Ninth Street is 70 feet wide between buildings, 50 feet between curbs; whilst south of that line it is but 40 feet wide, 26 feet between curbs, so that it would be necessary to widen it from Callowhill to Spring Garden. Fortunately there is a small street lying west of and nearly parallel to Ninth (Canton Street,) which is 30 feet wide, and, at the southern end, only about 8 feet distant from Ninth Street, while at its northern end on Buttonwood it is 96.9 distant. By purchasing this trapezoidal block of old buildings the space could readily be extended from

40 to 78 feet at Callowhill, and about 167 feet, if necessary, at Buttonwood. It only remains then to buy a strip on the west side of Ninth between Buttonwood and Spring Garden 30 feet wide to produce the full 70 feet width of Ninth Street through to Callowhill. This would provide for five or six lines of track on an elevated road, and furnish abundant room for all the traffic for many years. A depot at this site would be but an eight minute's walk from Ninth and Market. It is not proposed to abandon the line on Willow Street, but to use it merely for shipping the articles now manufactured by the numerous establishments to which it is tributary.

These two improvements, the tunnel and elevated road, would ultimately reduce the number of train-crossings by about 11,000, and enable the trains to make better time with less risk to all parties, thus removing the barriers to the east and south of that large and populous section lying north of Pennsylvania Avenue and west of Ninth Street. By transferring all the passenger travel from Third and Berks to Ninth and Callowhill, which could then be done, it would reduce the number of train-crossings on American Street and so lessen the casualties already too numerous in that section of the city.

Philadelphia, Germantown and Chestnut Hill Branch.

A glance at the location of this road shows a large elbow at Duy's Lane, whence the road runs for half a mile at right angles to its general direction. This location was made about 1830, when in wet weather the trains were run by horse-power. At that time the prospective travel was not sufficient to justify a more expensive location, but at present, both economy and convenience seem to require a revision of the road by which five-eighths of a mile might be saved, while the line would be brought nearer the most populous part of Germantown, yet not so as to interfere with surface travel, for it would be necessary to open a tunnel about 3,000 feet long under Main Street where a station should be built. The total length of the line connecting Wayne Street with that at Germantown would be less than 7,000 feet, and would form almost a straight line from Chestnut Hill to the Sixteenth Street junction.

To provide for the rapidly increasing population south-west of the Main Street in Germantown and Chestnut Hill, a new line is projected by the P. R. R. This branch will pass within half a mile of the Norristown Junction, to which it should be connected by a short line, thus enabling passengers to reach the centre of the city by the shorter route down Ninth Street, instead of making a detour of almost two miles further through West Philadelphia, for the present relations of these two great transportation companies ought not to be a bar to the convenience of the traveling community.

THE P. W. & B. R. R.

This line has over 2000 train crossings within city limits (the freight trains not being reported), and is located in a thickly settled part of the city, having numerous lines of street railways. It should be elevated from the crossing of the Delaware extension, to the elevator at its eastern terminus. Thus the ground plan of the city would be practically free from grade crossings, from Snyder to Alleghany Avenues, and from Front Street to the Schuylkill, and yet the railroad service be much more rapid and fully as efficient, whilst the public would be better accommodated. For efficient suburban traffic, the lines of railroad should not be more than about one mile apart, with stations at the same distance, thus limiting the time required to reach them to from eight minutes to zero.

TRANSPORTATION BY WATER.

Under this head I have very little to add at present, but there is one fact to which I desire to call attention. It has been customary for many years to ship nearly all of our foreign exports from the Eastern River front, making it necessary to transport a large amount of tonnage across and through the city, at great expense and inconvenience, only to be immediately trans-shipped to vessels and taken by them directly to sea. An inspection of the report of the Collector of Customs for last year (1880), shows the principle items of export to have been, of breadstuffs (corn, wheat and flour), $25,978,846; of petroleum and its products, $5,162,690; of bacon and lard, $5,818,145; of cotton, $2,883,820; and of coal, $208,237.

Of the above items a very small percentage require any manipulation or handling in mills or factories in the City, to prepare them for shipment and hence they might be loaded upon vessels at a point at least 7 miles nearer the sea thus saving the cost of that amount of transportation to the shipper. It was only recently that elevators were erected at Girard Point where a large amount of grain is now handled—and it is there that all of the extensive foreign commerce of the city should be located. There is good water at the mouth of the Schuylkill on either bank and room to extend the wharfage almost indefinitely by the construction of basins similar to those of the commercial cities of England. The Horse-shoe Shoals would be avoided with their dangers and delays, distance would be saved both on land and water, rents for the stevedores and employees would be less, the value of real estate is lower than that now occupied by the extensive elevators and warehouses in the built up part of the city and the interruptions and dangers to travel from the numerous and long freight trains, crossing the city streets at grade would be far less frequent. It would seem therefore a wise policy to devote that extreme southwestern section of the city to the interest of our foreign commerce.

ANNUAL REPORTS.

I. Annual Report of Treasurer,

January 11th, 1880, to January 10th, 1881.

The Engineers' Club of Philadelphia in account with Alfred R. Roberts Treas.

DR.

To Balance, Cash on hand Jan. 11th, 1880,	$136 45
" Annual dues,	603 75
" Initiation fees,	155 00
" Subscriptions to Proceedings,	145 00
" Sales of Proceedings,	14 70
" Deposits on keys,	17 50
" Sundry receipts,	9 72
	$1082 12

CR.

By Rent of Rooms,	$300 00
" Printing,	412 70
" Lithographing,	103 95
" Stationery,	97 15
" Postage,	37 20
" Distributing Proceedings,	6 44
" Keys to rooms,	13 80
" Expressage,	2 15
" Sundry bills,	2 22
" *Balance, Cash on hand Jan. 10th,* 1881,	106 51
	$1082 12

II. Annual Report of the Recording Secretary,

For the year 1880.

Mr. President and Gentlemen:

The third fiscal year of the Club will have ended with this meeting. During the past year, twenty meetings, comprising twelve regular, five business and three special, have been held, with an average attendance of nineteen members. At the regular meetings twelve visitors have been present.

The membership of the Club has been increased by the election of forty-two members, and decreased by the loss of ten members. In the present list of members we have three honorary, nine corresponding, and one hundred and thirteen active members, making one hundred and twenty-five in all.

The meetings of the Club and Board of Directors were suspended during the summer months. With this exception, the Board have held their regular monthly meetings and two special meetings.

The transactions of the Board contain but little of general interest to the Club, being essentially of a routine nature, for the approval of bills, nominations, etc.

No arrangement has been recommended in regard to the subject of joint publications, and the Proceedings will continue to be published as heretofore. At the last meeting of the Board it was decided to consider one volume of the Proceedings as comprising about three hundred pages.

Printed notices of all meetings have been sent to each member, but their sending has been sometimes delayed beyond the time specified in the By-Laws in order to include the report of the Committee on Information. In regard to this committee, I would suggest that its efficiency could be increased by placing it under the supervision of one permanent chairman, who could make appointments far enough ahead to control and arrange a suitable programme for each meeting.

The steady growth and progress of the Club during the past is a subject for congratulation and guarantee for its future success.

Very respectfully,

WILFRED LEWIS, *Recording Secretary.*

III. ANNUAL REPORT OF THE CORRESPONDING SECRETARY,

For the year ending January 8th, 1881.

Mr. President and Gentlemen:

I have the honor to present the following as the third annual report of the progress of the Engineers' Club of Philadelphia. As the report of the Recording Secretary will inform you as to the meetings of the Club which have been held during the year, and that of the Treasurer as to its financial progress and condition, I shall confine myself to other matters connected with the history of our third fiscal year.

It is unnecessary to reiterate the assurances of previous reports that the Club is upon a secure foundation and has unlimited prospect of interest and usefulness.

Our increase of membership is one decided indication of our

prosperity and of the necessity which existed for an organization of this kind in Philadelphia. When we remember that our beginning was a small and informal association of gentlemen, which met, in the residences of the members, for social intercourse and discussion of scientific topics of mutual interest, and that on December 17th, 1877, but little over three years ago, the first move towards organization was made, we should certainly feel much encouraged.

I have carefully compiled a list of the membership from the beginning, from which I have obtained and submit the following statement of our growth:

	Hon.	Cor.	Act.
Persons identified with the foundation of the Club and rated as Active Members, Jan. 19th, 1878, ...			23
1878. Additions, ...	2	7	27
			50
" Changed from Active to Corresponding,		2	2
		9	48
" Deceased, ...		1	
" Resignation, ...			1
	2	8	47
1879. Additions, ...		1	39
			86
" Changed from Active to Corresponding,		1	1
			85
" Deceased, ...			1
			84
" Resignations, ...			3
	2	10	81
1880. Additions, ...	1		41
" Changed from Corresponding to Active,		1	1
			123
" Resignations, etc., ...			10
	3	9	113

While it would appear from the foregoing that the *net* addition to our active membership was less by two members than during the previous year, it should be considered that the number of resident engineers, upon which to draw, has been diminished and that the failure to pass the constitutional amendment creating the class of non-resident members, at our last annual meeting has much to do with this. Several of the resignations received were no doubt due to the latter cause, and non-residents of Philadelphia have not felt that any compensating inducements have been offered them to join the Club.

One record in this connection should be made with thankfulness. This is the first year in our history, in which we have not been called upon to regret the loss by death of one of our members.

That to which we owe our greatest success and standing, at home and abroad, has been, as heretofore, our publication. Our Proceedings are no longer an experiment. We find that we are able to maintain them and, as the newer members of the Club have contributed so largely during the past year, we have much to expect from those members recently acquired and from the large number of persons who will unite with the Club before the expiration of the year. The relative place occupied by our publications and those of other local societies of the country, we leave to be determined by others, but we must not fail to hold our present position.

By the issues of the past year Vol. I has been completed and Vol. II has reached its 80th page, and we are happy to state that we were able to insert the seven illustrations in the last number without expense to the members. We are almost ready to go to press with another number, and the prospects are that it will be equal, at least, to any that have gone before it. But just here let me remind the members of the Club of the great importance of each doing his duty in contributing to this, which is the real result of the work of the Club. How few engineers, in any kind of practical experience, for even a few years, have not met with commonplace or peculiar cases of success or failure, a description of which would be of benefit to their professional brethren. Our method of bringing the information of the members before the

Club through a rotating committee, has many decided advantages; and may I not urge each of you, whenever a member thereof, which will be but for three consecutive meetings in the year, to always contribute *something*, be it ever so little.

It is most desirable that you should be present and read an original paper upon any engineering subject; next, if you cannot do this, that you bring for exhibition any drawings, photographs, models, etc., of engineering works or details of construction that may be at your disposal, but if this also is impossible, that you should read to the Club any extracts from engineering books or journals or items that may strike you as of special interest.

The Board of Directors has decided that our Proceedings shall hereafter be arranged in volumes of 300 pages more or less, that a regular subscription list for the same shall be continued, and that advertisements, of entirely appropriate character and not occupying more than sixteen pages, may be inserted. If any would consider it more desirable that the "*ads*" should be omitted, they should remember that they give to our publications an American character which should by no means be despised.

Endeavor has been made to obtain pound rates of postage for our Proceedings, and correspondence upon the subject with the authorities in Washington carried on, but so far in vain. While it is eminently proper that the many valuable newspapers and periodicals of the country should be distributed at the lowest possible rates, it is a *simple outrage* that a scientific society, the object of which is the dissemination of useful knowledge, should be compelled to pay over *four times* the postage required of the most insignificant county newspaper in the backwoods. A united effort on the part of the American scientific societies should be made to correct this evil.

During the past year the following original papers have been read before the Club:

Linkages for X^m, by Frank T. Freeland.

The Light House System of the Delaware River from the Head of the Bay to Philadelphia, by Edward Parrish.

Recent Improvements in Percussion Rock Drills, by F. L. Miller.

A Machine for the Solution of the Equation of the Nth Degree, by F. T. Freeland.

The Mexico and Vera Cruz Railroad, by Coleman Sellers, Jr.

Rapid Transit in Philadelphia, by L. M. Haupt.

A New Method for the Quantitative Determination of Combined Carbon in Cast Iron and Steel, by D. Townsend.

The Future Sewerage Requirements of Philadelphia, by Rudolph Hering.

The following notes and communications have been presented:

The Tay Bridge, by Messrs. Hering, Roberts and Murphy.

Water-way of Bridges in Worcester, Massachusetts, by T. M. Cleemann.

The Lowering and Boxing of the Egyptian Obelisk, by C. E. Billin.

The Goniometer Used on the Allegheny Portage Railroad, by A. R. Roberts.

Various Types of Locomotive Engines, by W. G. Neilson.

Early Railroading and Coal Trade, by Israel W. Morris.

A Method of Ascertaining the Day of the Week Coincident with a Given Date, by Frank T. Freeland.

A Method of Determining the Years in which February Has Five Sundays, by Frank T. Freeland.

The Maximum Flow of Rivers, by C. G. Darrach and Rudolph Hering.

Matsdaira's Instrument for Solving Triangles, by Howard Murphy.

An Instrument for Determining the Position of Slope Stakes, by H. A. Freeman.

A Submarine Explosion, by Frederic Graff.

An Improved Apparatus for Discharging Heavy Cargoes, by J. J. de Kinder.

The Metallic Flow in Cold Punched Nuts, by P. Roberts, Jr.

The Future Water Requirements of Philadelphia, by C. G. Darrach.

The U. S. Coast and Geodetic Survey of the Delaware River at Philadelphia, by Samuel L. Smedley.

Topographical Mapping, by A. E. Lehman.

Life and Works of Robert Fulton, by Samuel L. Smedley.

Coal Production and Waste, by A. W. Sheafer.

A New Self-Adjusting Crossing Frog, by A. R. Roberts.

A Day of the Week Coincident with a Day of the Month, by F. T. Freeland.

The Pollution of Rivers, by C. G. Darrach.

Narrow Gauge Railroads in McKean Co., Pa., by P. W. Sheafer.

Trial Run on Bound Brook Railroad, by A. R. Roberts.

The Ronquayral and Denayrouze Diving Apparatus, by J. J. de Kinder.

Link Valve Motion, by F. T. Freeland.

The Improvement of Shallow Rivers, by L. M. Haupt.

Improved Apparatus for Transporting Dredged Material, by J. J. de Kinder.

The Turntable of Penrose Ferry Bridge, by J. Milton Titlow.

Grant's Self-Cleansing Water Filter, by L. O. Towne.

The Large Anvil Block Cast at Park Bros., Pittsburgh, by C. T. Thompson.

A Pumping Engine for the Calumet and Hecla Mining Co., by Charles T. Thompson.

The Durability of Yellow Pine Railroad Stringers, by J. Milton Titlow.

The Etching of Cold Punched Nuts, by D. Townsend.

A New Fuel from Coal Tar, by D. Townsend.

A Specimen of Cast Iron of Great Tensile Strength, by D. Townsend.

The Fontaine Locomotive, by John T. Boyd

The Strong Feed Water Heater, by the Inventor, by invitation.

An Automatic Valve for Bilge Pumps, by J. J. de Kinder.

A Marine Signal Station on a Sand Foundation, by J. J. de Kinder.

Improvements Suggested in Railroad and Street Communication in Philadelphia, by L. M. Haupt.

The first notable event of the year was the reception of M. de Lesseps by the Club, upon his arrival in Philadelphia, an account of which has already been published in our Proceedings. The extreme shortness of the notice we obtained of his movements and of his stay in the city, allowed but little to be said or done, but we gladly embraced the opportunity to pay all possible

respect to M. de Lesseps as a distinguished visitor and as eminent in having conducted one of the greatest engineering works of the age, although it was not the intention of the Club to express either approval or disapproval of his particular scheme for dividing the American continent.

Following the de Lesseps reception came the very polite and attractive invitation of the American Society of Civil Engineers to participate in their annual convention, at St. Louis. Although the engagements of but few of our members, in addition to those who are also members of the American Society, permitted their attendance, it is, nevertheless, most gratifying and fraught with encouragement to the Club, that its relations with our representative and leading society should be of so fraternal a character. Those who went to St. Louis can only remember with the greatest satisfaction the cordial hospitality of the American Society and, in common with them, of the good citizens of that great metropolis. Every convenience and facility was placed at the disposal of the convention for the examination of engineering works and other objects of interest in St. Louis and vicinity, and each participant had reason to feel thankful for the acquisition of valuable professional information and for the enjoyment of the traditional good fellowship of the profession and hospitality of the South and West.

No action, perhaps, ever taken by the Club, was of greater public importance than the calling in convention at Harrisburg of all persons engaged in land surveying in Pennsylvania, for the consideration of means for "the improvement of the present methods of land surveying, the better location of county and other boundaries and the collection of information in regard to the geography and topography of the several portions of the state." The convention assembled and organized on October 27th, 1880, held five sessions, transacted business of great interest, appointed important committees and adjourned to meet at the call of the Executive Committee. As a full report of the proceedings of the convention will be published in the next number of our journal, we need not review them at this time, but as engineers and public spirited citizens we are to be congratulated upon our success, insofar as we have advanced, in

shaping results which, if achieved, must be of great benefit to the landholders of our Commonwealth and to all who should be entitled to practice the profession of land surveying.

A prominent topic of correspondence has been the proposed joint publication scheme, which originated, we believe, in the Engineers' Club of Cleveland. As the subject has already been presented to the Club, a detailed description thereof is uncalled for, and it is sufficient to state that the design of those interested is, to publish, in one pamphlet, all the proceedings of all the Engineering Societies in this country that will participate. The overtures which have been made to this Club have been respectfully considered, and a special meeting of the Board of Directors was held to give the matter full consideration, when it was determined that our having already contracted for the current volume of our Proceedings was a sufficient reason for our declining to take part and reply to that effect was sent. As, when we began to publish, a careful examination of methods was made and our present general plan determined upon; as our foreign exchanges furnish incontrovertable precedent for the successful maintenance of the publications of local societies; as we cannot attribute to flattery, but must modestly acknowledge, many at least, of the encomiums we have received; as it is most decidedly indicated that we shall be able to maintain our present standard; and as but one member of our Club is known to have expressed himself in favor of our participation, it seems more than likely that we shall continue to publish as heretofore.

The following Societies have been added to the exchange list of the Club:

- Pi Eta Scientific Society of the Rensselaer Polytechnic Institute, Troy, N. Y.
- Engineers' Club of Cleveland.
- Engineers' Society of Western Pennsylvania.
- U. S. Association of Charcoal Iron Workers.

And the following periodicals:

- The Ironmonger and Metal Trades Advertiser.
- Brick, Pottery and Glass Journal.
- American Engineer.
- United Service.
- American Architect and Building News.

Numerous contributions to the Library have been received, as gifts and in exchange for our Proceedings, acknowledgment of which may be found in the proper place in our Proceedings.

Very Respectfully,

HOWARD MURPHY,

Corresponding Secretary.

REPORT OF THE COMMITTEE ON LAND SURVEYING.

Presented December 4th, 1880.

To the Engineers' Club of Philadelphia:

The committee appointed to consider the subjects of improvements in present methods of land surveying, the better location of county and other boundaries, and the collection of material relative to the geography and topography of the State, respectfully begs to report:

That after holding a number of meetings, at which various plans for effecting the proposed reforms and improvements were considered, the committee decided to call a Convention of the Engineers and Surveyors of the State, in order that an opportunity might be afforded all persons interested to express their views concerning present methods and required changes. For the purpose of learning whether such a Convention would meet with approval among members of the profession, copies of the following circulars were sent to a large number of the surveyors and engineers in the State:

ENGINEERS' CLUB OF PHILADELPHIA.

1518 CHESTNUT STREET.

July , 1880.

Mr..

DEAR SIR:—

At a meeting of the Engineers' Club, held May 1st, 1880, the undersigned were appointed a committee on "Improvement of Land Surveying in Pennsylvania." The object in appointing the committee was that they "should take into consideration the subjects of *improvements in present methods of land surveying, the better location of county and other boundaries,* and the collection of material relative to the geography and topography of the State." It is thought that the best means by which to attain the objects

sought will be for all the surveyors of Pennsylvania to meet in convention, in order that they may discuss many important questions in connection with their work, position and compensation, and appoint special committees, from among themselves, whose duty it shall be to report to a future convention, on proposed plans and changes.

Will you please reply, at your earliest convenience, on enclosed blank forms, and oblige

Yours, very respectfully,

SAMUEL L. SMEDLEY,
LEWIS M. HAUPT,
W. C. CRANMER,
JOHN H. DYE,
CHAS. E. BILLIN, *Committee.*

ENGINEERS' CLUB OF PHILADELPHIA.

July , 1880.

Mr..................................... ....

....

DEAR SIR:—

Please fill in answers to the following questions and return at an early day.

Will you attend a Convention of the Surveyors of Pennsylvania, to be held in Harrisburg next fall?

....

Do you prefer some other place of meeting? If so, give name of City.

....

Which month, September or October, will be most convenient for you to attend Convention?........................ ....

Please mention subjects which you deem of most importance for consideration, and upon which the Convention should take some action........ ....

* * * * * * * *

Sign full name...

And address...

ENGINEERS' CLUB OF PHILADELPHIA.

July , 1880.

Mr...

DEAR SIR:—

Please send me a list of names and addresses of surveyors or Engineers in your County, whom you think will be interested in advancing the objects of the accompanying circular, and who should be invited to attend the convention.

Yours Very Truly,

CHAS. E. BILLIN,
Chairman.

* * * * * * * *

In reply to these circulars the committee received a large number of answers. The subjects suggested in these replies as important for consideration and discussion were as follows:

Best means by which all land measurement can be made perfectly horizontal.

Magnetic variation—its causes and value.

The location of a true meridian line in each county.

Surveying by true meridian to be made compulsory.

Fixing corners and marking lines.

The location of lines independent of the needle.

Fees and compensation of surveyors.

Instruments.

Location of street lines in boroughs where there are no original centre stones.

Grading of streets and sidewalks.

Abandonment of the needle.

A system of triangulation.

Examination of surveyors.

The location of county and township lines.

Maximum grade for roads.

Standard measures.

A better system of recording surveys.

Surveyors to be held responsible for their work.

The simplest method of determining the true meridian.

The probable cost of triangulation in each county.

Metric system.

The periodical tests of instruments.

The erection of permanent monuments.

The position of county surveyor to be made one of appointment.

The creation of a Board of State Engineers.

The correction and control of roads, bridges and streams.

In order that the work of the proposed Convention should attain definite results, the committee prepared an act, the several sections of which provided for carrying out some of the above important suggestions.

Arrangements were made with the Pennsylvania Railroad for the transportation to and from the Convention, and the following invitation sent to the surveyors and newspapers in the State:

ENGINEERS' CLUB OF PHILADELPHIA,

1518 CHESTNUT STREET.

September , 1880.

Mr ....

....

DEAR SIR:

You are cordially invited to attend, and participate in the discussions at a Convention of Surveyors and Engineers, resident in Pennsylvania, which will be held in Harrisburg, commencing Wednesday, October 27th.

In response to a preliminary circular issued by the undersigned Committee, a very large number of answers have been received. From these it appears to be the unanimous opinion, among Surveyors and Engineers of this State, that there are many much needed reforms, in connection with methods of land surveying, etc., and that a most valuable opportunity for the discussion of present methods, of proposed improvements, and of the position and compensation of Surveyors can be afforded by holding a Convention, at which time also special committees can be appointed, whose duty it shall be to report to a future Convention on proposed plans and changes.

The Penna. R. R. Co. have very kindly furnished the Committee with orders calling for the sale of tickets, at half rate, to Harrisburg and return, from all stations along the line of their several roads. Persons attending the Convention, and their families can obtain tickets at this reduced rate only upon presentation of an order for each ticket needed, and must notify the Committee immediately, as to how many orders they wish. Arrangements have been made for accommodations at the Lochiel Hotel, at the reduced rate of $2.00 per day. The Lochiel Hotel will be the headquarters of the Committee while in Harrisburg. Meetings will be held in Shakspeare Hall, Locust Street between Second and Third streets. The first session will commence Wednesday evening, October 27th, at 8 o'clock, when the Honorable Henry M. Hoyt, Governor of Pennsylvania, will address the Convention. Addresses, on some of the more important reforms which the Convention ought to consider, will be made by prominent Surveyors and Engineers. Sessions to effect organization and for general discussions will be held in the same Hall on Thursday and Friday (28th and 29th), at hours to be announced. An opportunity to visit the many points of interest in and about Harrisburg will be afforded persons attending the Convention.

Following are some of the many important subjects which have been urged upon the Committee's attention and which should be fully discussed in the Convention:

PROVISION BY STRICT LAWS FOR

Periodic Tests of Instruments—(Chains and Compass).

Horizontal measurement.

Establishment of standard measures and true meridians in each county.

Surveys to be recorded and plotted from true meridian only.

Marking corners and lines and the maintenance of such monuments or markings.

Retracing and permanently marking county and township lines.

The examinations of all surveyors as to their professional ability.

Surveyors to be held responsible for their work.

The abandonment of the needle in Surveying.

A more uniform system of fees and compensation to Surveyors.

There should also be consider the advisability of providing for a thorough Geodetic Survey of the State, of creating a Board of State Engineers, of making the position of Surveyor one of appointment by the judges, and prohibiting any but authorized Surveyors from recording work.

It is hoped that persons attending will be prepared to take an active interest in the work of the Convention and to give authentic data in regard to present methods of surveying, the condition of boundaries, marks, etc., etc., in their respective portions of the State. If surveyors will bring their transits, or compasses and chains with them an opportunity will be afforded for making tests of these. It is expected that several well-known instrument makers will have specimens of recent and approved forms of instruments on exhibition.

Surveyors who will not be able to attend the Convention in person are earnestly requested to send to

MR. CHAS. E. BILLIN,
Chairman of Committee on Land Surveying,
1518 Chestnut Street, Philadelphia, Pa.,

any remarks or suggestions which they may wish to have read before the Convention.

The Committee will be glad to receive the names of all persons who may be interested in promoting reforms and improvements in surveying and engineering work in this State, in order that invitations may be sent to them,

You are particularly requested to give the Committee an early answer whether you will be able to attend the Convention, and to state what transportation and accommodations you may desire.

Very Respectfully Yours,
SAMUEL L. SMEDLEY,
LEWIS M. HAUPT,
JOHN H. DYE,
W. C. CRANMER,
CHAS. E. BILLIN, Chairman.
Committee on Land Surveying.

ENGINEERS' CLUB OF PHILADELPHIA.

September , 1880.

Mr...

Editor of..

....

DEAR SIR:

We enclose to you an advance copy of a circular of the Committee on Land Surveying of the Engineers' Club of Philadelphia. The work undertaken by the Committee is very great, and we trust that owing to its importance to every interest of the Commonwealth, it will receive your kindly aid.

Will you please publish the circular in full, with such remarks regarding it, as you may deem best, in the columns of your valuable paper. The publicity thus given to it will be a material aid in furthering the work of the Committee.

Very Respectfully Yours,
CHARLES E. BILLIN,
Chairman of Committee.

At the request of your committee, the Engineer's Society of Western Pennsylvania, appointed a committee, consisting of Messrs. Fisher, Ehlers and Edeburn, to attend the Convention and to cooperate in advancing proposed reforms. These gentlemen rendered most efficient service in the work of the Convention.

Your committee met the surveyors of Pennsylvania in Harrisburg on October 27th, and organized the Convention. The following minutes of the Convention are submitted as showing the work done, and because they contain valuable information.

CONVENTION OF ENGINEERS AND SURVEYORS, RESIDENT IN PENNSYLVANIA, HELD IN THE HALL OF THE HOUSE OF REPRESENTATIVES, HARRISBURG.

MINUTES.

FIRST SESSION.—Wednesday evening, October 27th, 1880.—The meeting was called to order by Mr. Charles E. Billin, Chairman of the Committee on Land Surveying of the Engineers' Club of Philadelphia, who remarked:

"GENTLEMEN.—As chairman of the committee which issued the call for this Convention, permit me first to thank you for the hearty good wishes which you have all expressed for the success of the Convention. The committee have received a very large number of letters from prominent surveyors and engineers wishing us God-speed in accomplishing the object sought, viz., improvements in the methods and practice of land surveying, and the future organization of thorough geodetic work.

Our worthy Governor, Hon. Henry M. Hoyt, had intended to be with us, but is unavoidably detained in the eastern part of the State. I must, therefore, ask you to nominate a permanent chairman."

Upon motion, Hon. J. Simpson Africa was unanimously elected chairman of the Convention. Mr. Billin was elected secretary and treasurer, and, upon request of the chairman, stated that the objects for calling this Convention had been fully set forth in the circulars issued by the committee. The circular called attention to the following important subjects which have been

urged upon the committee's attention, and which should be fully discussed in this Convention: provision by strict laws, for periodic tests of instruments (chain and compass); horizontal measurement; establishment of standard measures and true meridians in each county; surveys to be recorded and plotted from true meridian only; marking corners and lines, and the maintenance of such monuments or markings; retracing and permanently marking county and township lines; the examination of all surveyors as to their professional ability; surveyors to be held responsible for their work; the abandonment of the needle in surveying; a more uniform system of fees and compensation to surveyors.

There should also be considered the advisability of providing for a thorough geodetic survey of the State; of creating a Board of State Engineers; of making the position of surveyor one of appointment by the judges, and prohibiting any but authorized surveyors from recording work.

The following gentlemen were present at the sessions of the Convention:

Ashburner, Charles A., Geological Survey of Pennsylvania, Philadelphia; Africa, J. Simpson, Surveyor and Engineer, Huntingdon; Africa, B. Franklin, Engineer and Draftsman, Huntingdon; Billin, Charles E., Engineer and Geologist, Philadelphia; Barker, Harry T., City Engineer, Beaver Falls; Brubaker, M. H., Landisville, Lancaster County; Boyer, H. S., Surveyor, Sunbury; by invitation, Burgess, C. H., Surveyor of Cleveland, Ohio; Cowden, M. B., City Surveyor of Harrisburg; Cheauvenet, S. H., Pennsylvania Steel Works, Dauphin County; Cloud, John W., Engineer of Tests, Pennsylvania Railroad, Altoona; Chance, H. Martyn, Geological Survey of Pennsylvania, Philadelphia; Dye, John H., Surveyor and Engineer, Survey Department, Philadelphia; Denny, John M., Surveyor, Butler County; Ehlers, Charles J. H., City Surveyor, Allegheny; Edeburn, William A., State Inspector, Pittsburgh; Ely, Samuel, Lancaster; Fisher, S. B., Assistant Engineer, Pennsylvania Company, Pittsburgh; Fry, Howard, Superintendent of M. P., P. & E. R. R., Williamsport; Fuller, John B., Surveyor, Lycoming County; by invitation, Frost, G. H., Editor *Engineering News*, New York; Gardiner, John, Department

Internal Affairs, Harrisburg; Gift, A. K., County Surveyor, Snyder County; Hough, David, County Surveyor, Mifflin County; Haupt, Prof. Lewis M., University of Pennsylvania; Irvine, O. M., Surveyor, Duncannonsville; Lehman, A. E., Geological Survey of Pennsylvania; Lehman, B. B., Department Internal Affairs, Harrisburg; Mercer, Joseph, Surveyor and Regulator Sixth District, Philadelphia; Meily, Martin, County Surveyor, Lebanon County; Miller, Preston, Pottsville, Pennsylvania; Merriman, Prof. Mansfield, Lehigh University; Nelson, T. M., Borough Surveyor and Agent Pittsburgh Bridge Company, Chambersburg; Peelor, David, Surveyor and Engineer Cambria Iron Works; Reifsneider, J. H., Centre County; Ritner, Joseph, Mechanicsburg, Pennsylvania; Smedley, Samuel L., Chief Engineer, Philadelphia; Soule, Richard H., Superintendent of M. P., N. C. R. R.; Smith, J. B., Waynesburg; Snader, Aaron W., New Holland, Lancaster County; Wilt, Adam, County Surveyor, Perry County; Vogt, Axel S., Altoona, Pennsylvania.

Mr. Smedley stated that the Convention was the outgrowth of a discussion on the subject of land surveying at the meetings of the Engineers' Club of Philadelphia. The Club deemed that reforms in such work are of very great importance and accordingly appointed a committee, with instructions that it should take such steps as it might think best, providing for permanent improvements in land surveying in Pennsylvania. This Committee requested the co-operation of the Engineers' Society of Western Pennsylvania and the latter have, by appointing a committee,—the members of which are at present with us,—identified themselves with the work.

A large number of communications from prominent engineers and surveyors, all heartily endorsing the proposed work of the Convention, were read by the Secretary.

The following extracts from these show the importance of the work undertaken:

GIRARD, ERIE CO., PENN'A, Oct. 20th, 1880.

CHAS. E. BILLIN, ESQ.:

Dear Sir:—I have delayed responding to your invitation to attend a convention of Engineers and Surveyors to be held in the City of Harrisburg until a late day, being in hopes that I would be able to be with you; but I find it impossible, and I must be content to express my views in regard to some changes that, in my opinion, are almost

necessary to be made in our present mode of surveying. I will commence upon the present system of "*County Meridians*."

The establishment of "Meridian Monuments" for each county I consider of no use whatever, except, perhaps, as a base to calculate the change of declination of the needle for the locality that you may be in; it would then be necessary to know how far you were from the monuments and also in what direction. Very few surveyors would take the trouble to ascertain this as closely as it should be done to insure uniform results.

The change of declination between the east and west sides of this county is nearly fifty (50′) minutes. On this parallel of latitude (forty-two (42°) degrees north) the change of declination equals about one minute to the mile as you move east or west, or in other words, at a point one mile west of the established meridian the declination of the needle will be one (1′) minute less than at the meridian, and *vice versa;* the same change of declination will occur as you change your position north or south, about one and eight-tenths (1.8) miles—moving north will increase your variation and south decrease the same.

To show the errors which may arise by a compliance with the present law in regard to meridians, we will suppose that a surveyor is called upon to run a line north from some point on the dividing line of two counties that lie east and west of each other, and that he shall use the variation called for by the meridian of the western county, and that meridian being twenty (20) miles to the west of the line to be run, he will, of course, carry with him (if located near this latitude (42°) north) twenty (20′) minutes less variation than he should, and will run his line, should he carry it one mile, thirty feet and one and a half inches into his own county, or to the west. Now, if the surveyor of the adjoining county east attempts the same thing, assuming that the meridian in his county should be twenty (20) miles to the east of the line to be run, he, in a like manner, will bring to his work twenty (20′) minutes too much variation, and will consequently, after running one mile, find himself the same distance to the east in his own county, and the points that each will locate will be sixty-one (61) feet and five and one-quarter (5¼) inches apart, assuming, of course, that the change of declination equals one minute to the mile and that the work is accurately done. The same difference will occur in running in any direction. As this is the case, surveys made in any part of a county will be in error in proportion to their distance from the county meridian.

We have surveyors in this county who seem to have but very little idea of variation and do fearful work in running through timber lands. I know of one especially, who commenced surveying in middle life because there were no surveyors in his neighborhood. After procuring himself a compass, he applied to me to assist him about getting the variation. I did so; and meeting him nearly two months afterwards with his compass, I found that he had drilled a hole through the vernier and compass plate and had actually rivetted it solid with a brass rivet. I found that he had the idea that, after ascertaining the variation once it was secured forever; his excuse for fastening it was that he was afraid that his children might move it and he would lose the variation. I had an application from another surveyor, who had purchased a transit, to put in the cross-hairs, as they "were gone" (to use his own expression). I found, after setting up the instrument that they "were gone" to him, but were in their proper places after focussing for them.

I merely mention this to show how a great part of the surveying is done in this county, and I presume that there are similar cases throughout the State. I often am called upon to trace lines that seem to have been run by surveyors of the class mentioned, and if I do not strike the same points it is intimated that I cannot be right. All surveyors, I feel confident, have more or less of this experience in this State, and will continue to have it so long as the profession is belittled (I know of no better term) by allowing persons to practice it without the slightest qualifications for its practice. Why should anyone be allowed to practice surveying without undergoing an examination as to his capabilities in the profession?

A law student is required to undergo the ordeal of an examination before he can practice in our Courts; likewise a medical or divinity student is examined as to his knowledge of the profession that he adopts before taking position as such. In fact, with the exception of the medical student (whose mistakes cannot be remedied), I think that an incompetent surveyor can make more real mischief than either of the other professions mentioned.

Now there is a way to weed out this class, and also insure uniform results in our surveys, and to do this I would propose to establish a system of triangles in each township, in the following way:—

Find in some part of each township (no matter where) a place where a line of 500 feet or more in length can be measured on ground which is nearly level. Make this line of a convenient length for a base, and measure it carefully a number of times, so that there shall be the least possible error (*for this measurement will govern all of the rest*); at the ends of this line permanent trigonometrical points should be securely established, so that there shall be no doubt as to their stability. Then at a point which will form an equilateral triangle, or as near as may be, with the base line for one side, set another permanent point; then measure the angles at each end of the base line carefully, in fact measure them many times on different parts of the circle and ascertain the mean of all, so as to reduce whatever error there may be in the graduation of the instruments as much as possible. Of course, after proving the correctness of your angles by measuring the angle opposite the base, it is easy ascertaining the length of the other two sides, which should be done by calculating them from the base and angles. The sides of this triangle would then answer the purpose of bases for other triangles.

A sufficient number of triangles should be permanently marked in each township, to be within reaching distance of any survey that could be desired within its limits.

At any time after the base is located, either before or after the triangles are finished, a careful observation should be taken from one end of the line on the Polar Star for the purpose of measuring the angle of the line with the true meridian, which, of course, would govern the actual bearings of the sides of the different triangles throughout the township. After this is completed it should be carefully plotted to a scale and recorded in the Clerk's office for the use of the profession. We will now suppose that we desire to make a small survey with the needle, we have only to place our instrument on a side of either of the triangles that is most convenient and ascertain the exact variation, then and there, and go on with our work.

Should another surveyor wish to trace this line a number of years afterwards, when perhaps the marks were obliterated and has only his record for guidance, he has only to place his instrument on the nearest side of one of the triangles and get his varia-

tions, and he can hardly help finding the line desired; and let the variation change more or less it will not effect the result, for he will get it for the exact locality and from unchangeable lines.

I do not say that my view of the case is the only way to remedy the evil, but in my mind it seems the most practical, as it does not entirely do away with the needle but will reduce the error of its use in surveying to its smallest limits; and until the community are willing to pay for more time in our surveys, we are almost compelled to survey with the needle, particularly in small areas. I most heartily wish that all surveying might be done by angles, for it would then prevent uneducated persons from practicing it, and the genuine surveyor could be held responsible for his mistakes.

There would, of course, be a slight error in the lines that are most distant from the original base, but the correction necessary can be easily determined. But I would prefer, if it can be done, that a law should be enacted that would compel the abandonment of the needle in all surveys that are to go upon record. It, of course, would make surveys more expensive, but it would save enough in litigation to more than balance the difference in expense, and would confine the work to the profession alone.

The expense of locating the triangle will, of course, be considerable, but when it is once done it is done forever, if not disturbed. The surveys made from these lines would not disturb the old corners or lines, but would record them as they are instead of where they were supposed to be.

In regard to the subject of plotting surveys by the true meridian, I can see of no other way, for as very few needles have the same declination there would be as many "magnetic meridians" as there might be instruments attempting to do the same work at different times.

On the subject of a geodetic survey of the State, I would say that it has become a necessity. A survey of the State would, of course, bring everything to a standard and every township could have permanent lines located; but until this is done we will be compelled to adopt some such plan as is spoken of in this article.

On the Subject of Marking Lines.

I cannot say that I have anything particular to offer on this, only whatever mode is adopted should be made uniform throughout the State, and made in such a way as will insure the permanency of monuments.

Examination of Surveyors.

This I consider an important matter; only let it be done as privately as possible, for many persons through a natural diffidence might fail to show their real knowledge of the profession. The best way to find out what a man knows about anything is to examine him when he is not aware of your intentions.

Periodic Tests of Instruments (Chains and Compass).

This should be done thoroughly, but as to how often I hardly know what to say. Every surveyor should know *at any time* if his instruments would do accurate work, and if held responsible for his errors would be apt to give them some severe tests occasionally. If he does not know how to test them he should not be considered a qualified surveyor.

Surveyors' Fees.

This will be a hard subject to deal with. Of all the professions the surveyor re-

ceives the smallest compensatiou, as a rule, and until it is "weeded" out no uniform rate can be depended on.

To refer again to the subject of meridians, I have no doubt that many will advocate the use of the solar compass.

This instrument is the best for extended surveys, where the change of variation would be considerable, but for general use it has too many adjustments to look after, and in unskillful hands might be a source of mischief. I would again say that so far as I can comprehend, standard lines in the locality to be surveyed are the only means for attaining uniform results.

Trusting that the deliberations of the convention may result in many reforms and cause the enactment of laws that will place the profession where it should be, and that is, *equal to any of the others,*

I am, very respectfully yours, etc.,

GEORGE PLATT,
County Surveyor for Erie Co., Penn'a.

HILLSIDE COAL AND IRON COMPANY.

Scranton, Pa., Oct. 21, 1880.

Mr. Chas. E. Billin, Chairman, etc.
1518 Chestnut St., Phila.

DEAR SIR:—Please pardon the delay in answering the circular inviting attendance upon the convention of surveyors and engineers at Harrisburg, the 27th inst. Pressing work is my excuse. I regret that business engagements will prevent the participation in a convention to be composed of the leading men in the profession, and the object of which is to place surveying upon a firm, reliable and business-like basis. You have my best wishes and heartiest sympathies.

I certainly do not err in saying that there is a vast room for improvement in every regard in this section of the State. "Stake and stones" or a convenient tree made good corners when the warrants were first surveyed. Upon the lands of the larger coal companies they have been replaced by monuments or faced stones, six inches square and from two to three feet long. But in many instances this was not done until almost every sign of corners and lines had disappeared. It is not surprising, then, that even among these companies that have taken measures to preserve landmarks, and employed the better class of the profession, there have been disputes and costly litigations. Going outside of these companies' lands you have chaos, or approach very nearly to it. Corners are oftentimes imaginary, and straight lines, so called, far from being the shortest distance between two points. Add to the want of guides upon the ground a lack of skill and knowledge upon the part of many surveyors, and the position in this neighborhood can better be imagined than described. In the language of politics, "there must be a change."

To bring about this change, the law of April 26th, 1850, ought to be amended so as to compel an examination of everyone desiring to practice surveying and the issuing of certificates to those passing the examination; to do away with the needle in surveying and to establish a true meridian for every group of four warrants. A State survey ought then to be made of each warrant and the corners permanently established.

Arguments in favor of examination are scarcely necessary. Those who are competent will not fear an examination and will not oppose; those who are incompetent will oppose, whatever the arguments.

The reasons for doing away with the needle and establishing a true meridian at each group of four warrants, are: the unreliability of the needle for correct work through yearly variation, diurnal variation and local attraction; the necessity of having a base line in ordinarily close proximity to any line that must be run. The unreliability of the compass is acknowledged by instrument makers, in not graduating the compass circle more closely than 15 minutes, and by mathematicians in making traverse tables for nothing less than 15 minutes. Trautwine gives latitudes and departures for smaller divisions than a quarter of a degree, but, as he intimates, the latter is intended for transit work.

Establishing a true meridian at the common corner of four warrants, the compass can be done away with most effectually. Let there be three monuments or stones, the corner of the warrants being one of them, in the meridian line, distance between two of the stones being exactly two rods or four rods, or, better, fifty feet. Setting a transit over the stone corner and sighting to the farthest stone in the meridian, will give a base line from which to turn off any angle desired, to run any piece of property in the four warrants of which the base line is the meridian established.

It may not be practicable to establish such meridian lines over the entire State at the present time, or in the near future, owing to the expense it may entail; but the system could be introduced in the most valuable and populous parts of the State and then gradually extended. Such a system will be more than valuable when Allegheny county becomes a Yorkshire, and Chester a Kent, in value of property and in population, and when the entire State supports as great a number of people to the square mile as Belgium.

Time will not permit me to say more upon the subjects mentioned by you or to advance arguments in favor of what I have but broached. Suffice it to say, that any method adopted by which there will be an improvement will receive whatever support and encouragement I am capable of giving it. Also, if there be another law passed by the State to regulate surveying and surveyors, let it be the duty of everyone interested to see that it is enforced and not become a dead-letter as the measure of 1850.

I am very sincerely,

W. A. May, *Engineer*,

H. C. & I. Co.

Sharpsville, Mercer County, Pa., Oct. 20th, 1880.

Charles E. Billin, Esq., Chairman, etc.

1518 Chestnut Street, Philadelphia, Pa.

Dear Sir:—Your circular inviting participation in the proceedings of a Convention of Surveyors and Engineers to be held at Harrisburg, commencing October 27th instant, is at hand.

One can hardly doubt that if all those engineers and surveyors who are strongly inclined to attend your convention could follow their inclinations, you would have a very large meeting. Like many others, I wish much to meet you at the time and place named, but cannot well do so.

I hope that the convention will not adjourn before having appointed, to report upon the several subjects named in your circular, select committees composed of men pledged to give to the subjects assigned them a careful, thorough and prompt attention, and to be ready with their reports at the time agreed upon; and I beg leave to suggest to the convention that each committee should render its report, to some designated person, in advance of the date fixed for the second convention, in order that the reports may be printed (if practicable, collectively, or at least in uniform style) and distributed, before the sitting of the second convention, to subscribing members of the organization to be formed on the 28th instant. I, for one, shall very willingly pay any assessment agreed upon by the convention as necessary for the purpose indicated.

The committee appointed to report on the matter of a Geodetic Survey of the State will have a very important charge. When it makes up this committee, the Convention ought to bear in mind the fact that no report on the subject will prove of any great value unless it is, obviously, the result of competent examination of its subject-matter, and a candid and exhaustive presentation of all the facts and figures necessarily to be considered by those who will finally have to act on the proposition for the making of such a map.

There will hardly be any dissent to the assertion that a good map of the State is much needed; but when the question is as to the probable cost of the map, or as to the plan best calculated to secure desired results, we shall need thoroughly-supported figures and incontrovertible statements of fact to make good our position as advocates for the making of the map, and our report should be framed with these considerations in view.

Your circular suggests providing by law for the appointment of surveyors by "the judges." If there is to be a Board of State Engineers (and Surveyors) would not that board, better than any other body or person, select and appoint surveyors? Should there not be competitive examinations of properly nominated candidates for the office named?

I hope that the Convention will appoint a committee to report on the now strenously urged proposition for imposing the French "Metric System" on the people of the United States. The voice of the Convention will be influential in the controversy now existing. As for me, I say: Decimal System—Yes; Metric Standard—*No!*

I am, sir, yours very truly,

J. M. Goodwin,
M. Am. Soc'y C. E's.

Upon motion of Mr. Ashburner, a committee of three—consisting of Messrs. Ashburner, Peelor and Denny—were appointed to frame rules for the government of this Convention.

Mr. Edeburn introduced Mr. Burgess, of Cleveland, secretary of the Association of County Surveyors of the State of Ohio. Upon motion, Mr. Burgess was invited to participate in the discussion at this Convention, and to state with what success the Ohio Association had met.

Mr. Burgess stated that an association was formed in Ohio

early last winter. A convention was held in January, and it is hoped we laid the foundation for good work in the future. We are as yet in our infancy, and knowing that you need all of your time at present for the discussion of important subjects, I will not detain you, but will take pleasure in giving desired information later.

Mr. Smedley stated that among the requirements of the day were better methods in the practice of surveying; better methods of making returns and records so that they may be of greater value to the community at large; and that the question of doing away with the use of the needle in land surveying, which at present is almost universal, should demand the earnest attention of the Convention.

Mr. Ashburner, chairman of Committee on Rules, reported that the committee deemed it advisable to make only a preliminary report, intending to make a full report of rules for the government of the Convention at the next session.

The committee recommended that debates be limited to five minutes, that a subscription of one dollar be solicited from each gentleman present, for the purpose of meeting the expenses of the Convention, and that the morning session of the Convention should commence at 9 A. M.

Mr. Smedley moved that an Executive Committee of nine gentlemen be appointed, to whom all questions pertaining to legislation with respect to land surveying, be referred, and that they be empowered to prepare a bill for presentation to the legislature.

After considerable discussion as to the method of the appointment of this committee, Mr. Smedley's motion was carried, leaving appointment to the chairman of the Convention.

Upon the motion of Mr. Gardiner, such rules of the House of Representatives as were applicable were adopted for the government of the Convention.

Mr. Smedley stated that the committee of the Engineers' Club of Philadelphia had prepared an act, consisting of twelve sections, for the consideration of the Convention. It was not the idea of the committee that this act in its present form would be adopted, but by putting their ideas in this shape they hoped to elicit dis-

cussion and give a definite basis for work in the Convention. The committee had been working entirely with the view of obtaining much needed reforms and not for the purpose of carrying out the ideas or advancing the interests of any special section of the State.

The act was read by the Secretary, and upon motion of Mr. Chance, was referred to the Executive Committee, with power to act thereon. After considerable discussion as to the power thus given to the Executive Committee, they were requested to report to the Convention at as early an hour as possible to-morrow, and the Convention adjourned.

MORNING SESSION.—October 28th.—The Convention was called to order at 9 A. M., Hon. J. Simpson Africa in the chair.

Mr. Ashburner, chairman of Committee on Rules, reported as follows:

The Committee on Rules and Order of Business respectfully beg to report the following rules:

1. Those governing the meetings of the House of Representatives of Pennsylvania, when deemed applicable by the chairman of the Convention.

2. No one member of the Convention shall speak more than twice on any one resolution or subject, nor for more than five minutes at any one time, without a majority vote of the Convention. The committee wish to elicit a free and liberal discussion on all topics from all the members present.

And the following order of business:

1. Reading of minutes of the last meeting.
2. Unfinished business.
3. Deferred business.
4. Reports of committees.
5. New business.
6. Adjournment.

The report was adopted and committee discharged.

The chairman of the Convention appointed the following gentlemen to serve on the Executive Committee: Messrs. Smedley, Edeburn, Brubaker, Peelor, Dye, Ritner, Fisher, Boyer and Denny, to which were added, on motion, as ex-officio members, the officers of this Convention.

Upon motion of Mr. Dye, the Secretary was instructed to omit from the minutes all motions which were withdrawn.

Upon motion of Mr. Smedley, Mr. Geo. H. Frost, Editor of *Engineering News*, was invited to participate in the discussions of the Convention.

Mr. Smedley stated that it is very desirable for the Executive Committee to consider all subjects of importance which are brought before this Convention, and further requested that gentlemen having any suggestions to make in regard to legislation would please submit them to the Committee. At the request of the Convention, Mr. Smedley reported back the proposed act for discussion. The act was then carefully discussed section by section, many important changes being made.

In section 1 the question of qualification of the proposed State engineers and surveyors brought out much discussion. From this the following points of general agreement are taken: Any examination of these officers is impracticable; the amount of practical experience to be required is a secondary consideration, for many instances of good judgment and work among young engineers and surveyors, and a lack of judgment among older men, were cited. The first appointments will regulate very greatly the importance of the office; a recommendation to the Governor, by a permanent organization of the engineers and surveyors of the State, of men to fill these positions, will probably lead to better results than any other method. We have not as good County Surveyors now, by election, as when they were appointed by the Surveyor General.

In the discussion on section 2, Major Hough stated that not one-half of the township lines are marked, and even the location of county lines are not known. The record of a part of one line between Mifflin and Huntingdon counties, reads that "the said line shall begin 160 rods south from "Drake's sign-post," a point now undeterminable by even the "oldest inhabitant." In the recent purchase by a company of 40,000 acres of land, by reason of overlapping brought out by re-surveys, the company lost 3,600 acres.

Mr. Ashburner offered the following resolution which was unanimously adopted:

Resolved, That the surveyors of the Commonwealth of Pennsylvania assembled in Convention at Harrisburg, October 28th, 1880, having empowered the chairman of the Convention to appoint a committee to constitute an Executive Board to direct any action on the part of surveyors looking toward survey reforms, recommend: That this board so appointed constitute themselves a permanently organized body to call surveyors' conventions and to organize and direct all movements which may accomplish the reforms this Convention deem so necessary. It is the opinion of this assembly that this Executive Board should be dissolved after the adoption of their report by the Surveyors' Convention next following the Convention at which they have been appointed, and that a new committee be appointed at each succeeding Convention.

It is further resolved, That the Executive Board shall not have the power to propose to the legislature of this State the enactment of any act except by and with the approval of a Surveyor's Convention, to whom they shall propose such action as they may deem desirable.

Resolved, That the chairman of the Executive Committee be empowered to fill by appointment any vacancy occurring in the committee.

Upon motion, the Convention adjourned until 2 P. M.

THIRD SESSION.—The Convention was called to order at 2 P. M., the Hon. J. Simpson Africa in the chair.

The consideration of the sections of the proposed act was continued. The act as amended was referred to the Executive Committee, and the Convention adjourned to meet at 8 P. M.

FOURTH SESSION.—The Convention was called to order at 8 P. M., Hon. J. Simpson Africa in the chair. The secretary read the following interesting communication from Mr. J. B. Kaufman of Franklin County:

Upper Strasburg, Franklin Co., Pa.

Charles E. Billin, Esq.

DEAR SIR:—Your circular dated September, 1880, inviting me to attend and participate in the discussions at a Convention of Engineers and Land Surveyors to be held in Harrisburg is received. It would afford me great pleasure to attend and until to-day I had hoped to be present but obstacles have unexpectedly come in the way, and it is with deep regret that I find that I will be unable to attend this Conven-

tion. The movement, however, meets my warmest approval, and reforms, as contemplated, are much needed. The present methods of land surveying, practised in this and adjoining counties, are extremely crude and defective.

Nearly all surveys are made with needle instruments and the old fashioned two pole chain.

Very few surveyors use instruments capable of measuring angles independently of the needle or of obtaining solar observations, nearly all contenting themselves with the plain or vernier compass, the former kind as yet predominating.

When it is remembered that in this County are several broad belts of iron ore lands some portions of which are magnetic, manifesting strong local attractions, it is easily seen how unreliable our best needles become, yet how much more unreliable are those old worn out, bent up, badly adjusted, badly centred instruments, with sluggish needles, which are so frequently used to retrace and establish lost lines and corners and supposed to be *just* the thing because *the needle settles quickly*. Some of our Surveyors use good instruments of the kind, and exercise care and their work is generally accurately done. Five or six surveyors in this county return their drafts by the true meridian, the rest—say about four-fifths of the whole—make out their drafts by the magnetic meridian, in disregard of the law enacted in 1850, and their work ranks correspondingly low and unsatisfactory, in several other respects.

As far as can be ascertained, there are now in use among our Land Surveyors in this County, One Solar Transit, Two Surveyor's Transits, Four or Five Vernier Compasses, and some Twenty Plain Compasses. Many of the last named have no levels of any kind to set the instrument horizontal.

Chaining is frequently done in a still more inaccurate manner. In nearly every instance the chainmen are furnished by the land owner either hired by him, or taken from his farm hands, but more frequently is the work done by turns by the neighbors who may happen to be present to "see the lines run along their own lands," whilst as soon as their tracts are passed they quietly disappear, and some one else has taken their place. Little effort is made to measure straight or to keep the chain straight and taut, or to carry it level over hills and valleys. Frequently the men are too inexperienced to know how to make the outs properly, or give a correct report of the pins. Frequently it seems as if employers thought that skill, care, and intelligence had nothing to do with chaining, judging from the qualifications of the hands they furnish.

How surveys made under these circumstances are expected to close or balance properly, I leave to the imagination of my fellow-laborers, who may possibly have had experiences of this kind occasionally.

I would not, however, have it understood that all our surveying here is done in this slip-shod, hap-hazard sort of style. On many occasions good, careful, honest and intelligent men are employed who do the work as directed, do it creditably and accurately, and the result is satisfactory when completed, but in the majority of instances, there is more or less of carelessness and stupidity displayed.

When this County was first surveyed, the greater part of it was well timbered and the lines and corners were marked by blazing and notching trees. In places where timber was scarce, the corners were generally marked by a "post," a stone, or by a stone heap. Owing to the clearing out of the timber and other causes many of these marked trees have died, or have been cut down by the owners of the lands whose boundaries they marked. Some of them have been replaced by a stone sunk in the

ground, some by driving a marked or unmarked stake in the ground, while in too many instances all traces of marks have long ago disappeared. Hence, it is often quite difficult to find the exact spot where the original corner stood, especially as owing to the uncertainty of the exact amount of variation to allow for the course, and the still greater uncertainty of the correctness of the old measure, and not very much better chaining in our day, it is often hard to tell which way to go, or when to stop.

In some neighborhoods most of the lines and corners have been adjusted and marked with substantial stones deeply sunk in the ground, whilst in others a great deal of carelessness seems to prevail. Again there are localities where corners will not remain any length of time no matter how well marked. But when lands are surveyed it too frequently happens that the owner has not prepared proper material to mark corners, so when the point is established he points a piece of half rotten rail, tells the surveyor to "call it a stone in his draft, that some day he will put a stone in;" but forgets to do so, and six months after he cannot find the stake he placed there and the corner is lost again. All these causes have led to much uncertainty, disputes and law suits, whilst the profession has been lowered in the estimation of the public.

If this state of things exists elsewhere as well as here and I doubt not it does, as shown by the reports from different portions of the State to the Secretary of Internal Affairs; then there is indeed room for reform. But what is the proper remedy?

A number of plans, any of which would be a decided improvement upon past and present methods, have been suggested.

One of them is, for the Coast Survey Office to make a Geodetic Survey of the whole territory embraced within the limits of the Commonwealth, or it might be done by a State Board of Engineers and at the expense of the Commonwealth. Perhaps a better plan would be for the National Government to employ the Coast Survey Office to determine with their large Transits and admirable instruments, the primary triangles and mark them properly, the State Engineers make the secondary triangulation and perhaps the tertiary triangles, or perhaps it might be done by each County should the tertiary system of triangles be small enough in extent to justify the use of the ordinary transit in measuring the smaller triangles. From these lines and stations, properly marked and perpetuated, farm, township and County lines could be determined by triangulation with assured accuracy, and thereby dispense to a great extent or altogether with lines run by the needle and with chain measurements, except perhaps very short lines. Records of triangulation points to be kept up in the County, as well as of the sides of the triangles and the azimuth each makes with the true meridian. If tracts were measured by this system lost lines and corners could be restored with a degree of accuracy never attainable by the present method. No survey to be legal except such as are made by properly authorized persons, and with instruments capable of taking angles independently of the needle.

This would rid the community of incompetent surveyors, inferior instruments and do away with the defective system (or want of system) so long in vogue, and which has caused so much trouble in the past. I would be in favor of some system as above outlined. Another plan is to survey the whole State in blocks of one mile square and mark the intersection points with proper monuments, from which lines of tracts could be triangulated. This plan would be very good were it not the intersection points would necessarily fall into very inconvenient points to work from—in the midst of fields, in ravines, in the heart of forests—points difficult to find and often unsuitable

to work from. Besides, the monuments would not be likely to be well taken care of if in the middle of a grain field. By the other plan the triangulation points may generally be selected according to the suitability of position, etc.

Whether a geodetic survey would be impracticable on account of too great expense I would not undertake to say, not having sufficient acquaintance with the subject to be able to judge, yet when we consider what vast sums are annually spent in land trials, besides the great cost entailed on each county, the individual costs, it seems to me it would ultimately pay to have something of the kind done; but, as it may possibly be deemed too expensive to do it now, and as it may be years before it would be accomplished, even if begun now, then it becomes a serious question how to improve the methods so as to secure better work and fewer disputes about lines. A good deal could be accomplished by laws forbidding the use of the needle and requiring surveyors to use angular instruments or the solar compass, requiring horizontal measurements and light, strong chains. In measurements a good deal could be done if surveyors could select the chain men, who would be more fully under his control. Then if the law would allow none to survey except properly qualified or authorized persons, better work would be done. As it now is, competent surveyors, even with good instruments, have the alternative to use the cheap, rapid and more imperfect methods, or have nothing to do most of the time. As long as surveyors, or persons calling themselves so, who handle ten dollar compasses are as plenty as they are now, persons will employ them because they are cheap and they are unwilling to pay fees commensurate with the time, labor and skill bestowed on a more perfect survey. So, unless the more competent surveyor would see the greater part of the work done by those men (by some termed bushwackers), he must work for small fees and hurry over the work as soon as he can, though it be under protest. Unless something is done to rid the profession of this class of men, who degrade the profession, it is likely that the greater part of the surveying will continue to be done with needle instruments for a good while to come.

Even if we survey by the angular methods, as all the surveying has been done with needle instruments, it becomes necessary, in order to retrace lines correctly, to know the amount of variation that has taken place since the original survey was made from which the lines are sought to be retraced. For this reason the law of April 26th, 1850, requiring surveyors to compare their compasses with an established meridian line and adjust their chains with a standard measure, is a wise one and has done a great deal of good, notwithstanding its only partial observance so far. Had all observed it and every year tested their instruments, made the proper record of their tests and all made out their drafts according to the true meridian, the good effects would have been very much greater. Again, if the law required the tests to be made on one day in the presence of each other, the tests would be much more valuable than if made on different days, as that would produce more uniformity, eliminating one element of uncertainty, viz., the diurnal change, as the instruments would be affected equally or nearly so if done the same hour.

Our meridian was established late in 1851, but of late years, especially since the war, few entries have been made in the Survey Book. This year a large number have recorded their tests, and it is to be hoped surveyors in the future will more generally observe the law, much as it might be improved, and that in the counties where no meridian lines have been established they will not fail to have them established.

I am aware that many surveyors have, or affect to have, little faith in meridian lines. While it is true that the needle plays strange pranks at times, and the most experienced surveyors can at best run only an approximate line at first and must resort to marks and other information, it is an undeniable fact that where the present law is observed the results are more uniform than where it is disregarded. I might speak of methods and formulæ for finding the amount of change of declination for various periods since the original settlement of the State, but want of space forbids at this time.

I very much regret that I cannot be with you, and I feel considerable disappointment in being deprived of the pleasure anticipated. It would have been especially pleasant to have become personally acquainted with many of my brother surveyors and engineers whom I know by reputation only, but whose productions I have perused with heartfelt satisfaction and profit, but with whom I have never been so fortunate as to be personally acquainted. Always desirous and willing to learn, I know that I would never have had occasion to regret attending your deliberations. Warmly sympathizing in the cause, and hoping the labors of the Convention will be productive of well matured plans and measures that may elevate our profession to a higher sphere of usefulness, I remain,

Very respectfully yours,

JOHN B. KAUFMAN.

Mr. Smedley, chairman of the Executive Committee, reported an act consisting of thirteen sections, and the report was accepted. The act is as follows:

AN ACT TO PROVIDE FOR THE BETTER REGULATION OF SURVEYS IN THE COMMONWEALTH OF PENNSYLVANIA.

SECTION 1.—*Be it Enacted, etc.,* That the Governor, by and with the advice and consent of the Senate, be and his hereby authorized and directed to appoint two competent and practical surveyors, who shall have had at least ten years practical experience in their profession, and who shall be citizens of this Commonwealth at the time of their appointment; who, together with the Secretary of Internal Affairs, shall form a board to be styled the Board of State Surveyors, of which the Secretary of Internal Affairs shall be the president, by virtue of his office.

At the first appointment, one of the said surveyors shall be chosen to serve until the third Tuesday of January, Anno Domini 1882, and the other shall be chosen to serve until the third Tuesday of January, Anno Domini 1884, and thereafter, their successors shall be chosen from among the licensed surveyors for the full term of four years. The said surveyors shall receive an

annual salary of—*—dollars, but this is not to be construed to increase the salary of the Secretary of Internal Affairs, which shall remain as heretofore fixed by law.

SEC. 2.—The duties of the said Board of State Surveyors shall be as follows: They shall examine candidates for the practice of land surveying in this Commonwealth, and issue licenses under seal to those who, after examination, they shall deem competent. They shall establish, or cause to be established, true meridian lines in connection with standard United States measures of one hundred feet and parts thereof, in some suitable place, or places, in each and every one of the counties of this Commonwealth. They shall examine and approve the instruments and measures to be used by all licensed surveyors, at such times as they may deem necessary, and no instrument or measuring line shall be used in any of the surveys hereinafter specified, without having received the previous approval of this board.

They shall establish such rules and regulations in the practice of surveying, as shall insure the most accurate work and the best means of establishing permanent monuments. All lines shall be run to the true meridian, and the magnetic bearing also noted. Every surveyor shall subscribe his name and the date of survey to every map of survey. They shall exercise all the powers and perform all the duties heretofore exercised and performed by the Board of Property, and shall be subject to all laws now in force, applicable to the said board last mentioned.

SEC. 3.—The Board of Property, as now organized, consisting of the Attorney-General, the Secretary of the Commonwealth, and the Secretary of Internal Affairs, is hereby abolished.

SEC. 4.—No person shall hereafter be eligible to the office of County Surveyor, as authorized by existing laws, unless he shall have been licensed by the State Board of Surveyors as a Land Surveyor for the term of five years from the first day of January next following the date of such appointment. The person so elected shall, before entering upon the duties of his said office, in addition to the oath prescribed by law for county officers, take and subscribe an oath or affirmation to perform all of the several duties of his said office with fidelity.

The judges of the Court of Common Pleas shall have power,

on cause shown, to remove any of the said County Surveyors, for neglect, refusal, incompetency or inability to perform the duties of his office, or for conviction of any infamous crime or misdemeanor. In case of any vacancy occasioned by death, resignation, removal or otherwise, it shall be the duty of the said judges of the proper county to appoint a qualified person to fill such vacancy for the unexpired term.

SEC. 5.—It shall be the duty of the County Surveyor to make such surveys and returns as are required by law. He shall keep in books to be provided by the county for that purpose, a record of all surveys made by himself, or by other licensed surveyors in the county, plotted upon such scale, or scales as may be established by the Board of State Surveyors, and showing distinctly and accurately the position of the property, the bearing of all lines by true meridian, noting the magnetic bearing and variation, the length of lines by United States standard, the position and character of landmarks, the names of adjoining owners, the name of the owner or person for whom the survey was made; in case of the survey being made by deed, the date and place of record of the deed; in case of contested lines, the names of adjoining owners who were present at the time the survey was made, the name of the surveyor, the date of his license and the date of the survey. He shall, within ninety days from the completion of the work thereon, forward a plan of all such surveys, so made or recorded by him, to the office of the Board of State Surveyors.

SEC. 6.—From and after the first day of January, Anno Domini 1882, it shall be unlawful for any person to practice the profession of land surveying, except as hereinafter provided, until he shall have passed a successful examination before the Board of State Surveyors and been duly licensed by them, and shall have taken and subscribed, before one of the judges of the Court of Common Pleas, an oath or affirmation to perform his duties as a land surveyor with fidelity; which oath or affirmation shall be filed on record in the office of the Board of State Surveyors. Any person violating the provisions of this section shall be liable to a fine of one hundred dollars for each and every offence, to be recovered as debts of a like amount are now by law recoverable.

SEC. 7.—It shall be the duty of every licensed surveyor, within thirty days after he shall have made a survey within any county, to return to the County Surveyor of said county duplicate plans of the survey so made by him, drawn accurately to such scales, and showing all such details as are or may be required by the provisions of this act and the regulations of the Board of State Surveyors passed in pursuance thereof. He shall conform to all the rules and regulations which may be adopted from time to time by the said board for the government of land surveyors, and shall submit his instruments and measures to the inspection of the said board, whenever reasonably demanded by them.

SEC. 8.—That from and after the first day of January, Anno Domini 1882, in all surveys made within this Commonwealth, fixing the location of county, township or property lines, the use of the magnetic needle must be avoided as far as possible and the angles of intersection of all lines given from the vernier, and all measurements in surveys shall be made with improved steel measuring chains, lines or rods, or such other accurate methods as may be allowed by the board to be tested by the standard United States measure, and shall be reduced to horizontal measurement.

SEC. 9.—That from and after the first day of January, Anno Domini 1882, all licensed surveyors, in marking the corners or angles in surveys of property, or of roads after the final location of said roads made by them, shall, wherever practicable, use landmarks made of stone, not less than twenty-four inches long, with one end squared five inches by five inches. In marking the lines of townships, they shall use landmarks of stone not less than three feet long, one end squared eight inches by eight inches, set in the ground so as to project six inches above the surface; and for marking the lines of counties they shall use landmarks of stone not less than four feet long, one end squared twelve inches by twelve inches, and a hole drilled one-half of an inch in diameter and one inch and a half deep, set in the ground so as to project twelve inches above the surface.

SEC. 10.—Any person who shall knowingly or maliciously alter or remove any stone or other landmark, marking the line of any county, township, road, street or property, shall be guilty of a

misdemeanor, and, on conviction, be sentenced to pay a fine not exceeding five hundred dollars and to undergo an imprisonment of not exceeding one year.

SEC. 11.—It shall be lawful for any licensed surveyor, with or without his assistant or assistants, to enter into or upon the lands of any person or corporation at any reasonable hour, in the performance of his duty as surveyor.

SEC. 12.—Engineers actually in the employment of any railroad, canal or other corporation of this Commonwealth, shall not be subject to the provisions of section sixth of this act, in making surveys for the purposes of their respective corporations, excepting the fixing of property lines, but it shall be the duty of such engineers, within ninety days after the completion of the work hereon, to return to the County Surveyors a plot of every survey so made by them in any county, prepared in accordance with the requirements specified in section seven of this act.

SEC. 13.—Nothing in this act contained shall be construed to prevent any person from making surveys within the boundary or containing lines of any land for the purposes of landscape gardening, laying out cemetery lots, and the like; nor shall any of the provisions of this act be construed to impair, alter, repeal or otherwise affect any existing law providing for the election of surveyors and prescribing the duties thereof, in any of the incorporated cities, towns or boroughs in this Commonwealth.

SEC. 14.—That from and after the passage of this act, whenever a licensed surveyor is requested to attend court as an expert witness to testify to the accuracy of his work in the location of disputed lines, he shall be entitled, in addition to his mileage, to the sum of five dollars per day, to be taxed as ordinary costs in the case.

SEC. 15.—For each and every draft or plan filed, copied and forwarded to the Board of State Surveyors, as provided in section six of this act, the County Surveyor shall receive, in addition to such other fees as are now allowed by law, the sum or fee of one dollar and fifty cents, to be paid by the parties having the surveys made.

Upon motion of Mr. Chance the Act was read, section by section, which, after consideration, was adopted.

Upon motion of Mr. Dye the following committee of seven were appointed to consider the subject of fees of county surveyors; Messrs. Irvine, Hough, Snyder, Denny, Alricks, Reifsnider and Wilt.

Upon motion of Mr. Ritner, Section 14 (as given in the Act above) was introduced, after which the Convention adjourned.

FIFTH SESSION—Oct. 29th, 1880.—The Convention met at 9 A. M., Hon. J. Simpson Africa in the chair. Mr. Irvine, Chairman of the Committee on Fees of County Surveyors, reported the recommendation of section 15, as given above. The committee further reported that they considered it inexpedient to incorporate in this Act any stipulated fees for the work of surveyors, thinking it better that this subject should be left to the decision of individual surveyors and to the regulation of circumstances. Upon motion, the report was adopted and the new section ordered to be incorporated in the proposed Act.

The following resolution, offered by Mr. Irvine, was unanimously adopted.

Resolved, That the Executive Committee be, and are hereby directed, to prepare a constitution and by-laws for the more perfect organization and government of future Conventions, and to report the same to the next Convention; and that when this Convention adjourns, it be to meet again at the call of the Executive Committee.

The following resolution was offered by the Secretary and unanimously adopted:

Resolved, That the Bill adopted by this Convention, and proposed to be submitted to the Legislature, shall be referred to the Executive Committee, with authority to correct any errors in verbiage or construction, so as not to change its intent or meaning, with direction to them to cause it to be transcribed and printed for presentation to the next meeting of the Legislature.

After a general discussion on the subjects of magnetic variation, fees for surveying, and organization of county associations, the Secretary stated that it is very important for the use of the Committee in calling the next Convention, that a full list of all persons engaged in the practice of surveying in this state should be secured; for this reason all surveyors are requested to send to the

Secretary, at 1518 Chestnut street, Philadelphia, full lists of all persons who practice surveying in their respective counties.

On motion of Mr. David Peelor, a committee consisting of Messrs. Peelor, Haupt and Kaufman, was appointed to consider the subject of magnetic variation, and to report upon the same at the next Convention.

The following resolutions were introduced and unanimously carried:

Resolved, That the thanks of this Convention are due and are hereby tendered to Hon. J. Simpson Africa, for the grace, courtesy and good judgment with which he had presided over its deliberations; also to Mr. Charles E. Billin, for his faithful and untiring services as Secretary; to Hon. A. K. Dunkel, Secretary of Internal Affairs, and to his deputy, Mr. John Gardiner, for their attentions and courtesies, and to Mr. Wm. P. Small, Resident Clerk, for the privilege of using the Hall of the House of Representatives for its sessions.

Resolved further, That this Convention desires to express its indebtedness to the press of Harrisburg for the full reports which they have published.

Upon motion the Convention adjourned to meet at the call of the Executive Committee.

CHAS. E. BILLIN, Secretary.

Through the Executive Committee of the Convention of Surveyors, the work of carrying out improvements in land surveying proper, has been provided for. The work of collecting material relative to the geography and topography of the state, which was also confided to your committee has not yet received special attention. With the hope of accomplishing this and aiding in the promotion of geodetic work in the state, we would respectfully ask that the committee, as such, be continued.

SAMUEL L. SMEDLEY,
LEWIS M. HAUPT,
JOHN H. DYE,
W. C. CRANMER,
CHAS. E. BILLIN, Chairman.

APPENDIX.

The Executive Committee of the Convention, with the advice of the Governor of Pennsylvania, have submitted to the Legislature an Act somewhat different in form and provisions from that adopted at the Convention. The following is the text of the Act, which at present (February, 1881) is under consideration in the Legislature.

AN ACT, TO ESTABLISH A STATE BOARD OF SURVEYORS, AND TO PROVIDE FOR THE BETTER REGULATION OF SURVEYS IN THE COMMONWEALTH OF PENNSYLVANIA.

SECTION 1.—*Be it enacted, etc.*, That the Governor be and he is hereby authorized and directed, as soon as practicable after the passage of this Act, by and with the advice and consent of the Senate, to appoint two competent Surveyors, reputable citizens of this Commonwealth, who shall have had at least ten years practical experience in their profession, who, together with the Secretary of Internal Affairs, shall form a Board to be styled the "STATE BOARD OF SURVEYORS," of which the said Secretary of Internal Affairs shall, ex-officio, be the President. One of said Surveyors shall be chosen to serve until the third Tuesday of January, one thousand eight hundred and eighty-two, and the other shall be chosen to serve until the third Tuesday of January, one thousand eight hundred and eighty-four; and thereafter their successors, possessing like qualifications, shall be chosen from among the Licensed Surveyors for the full term of four years. The said Surveyors shall each receive an annual salary of dollars; but this shall not be so construed as to increase the salary of the Secretary of Internal Affairs.

SEC. 2.—It shall be the duty of said Board, a majority of which shall constitute a quorum, to meet statedly at the capital of the Commonwealth, (at least four times in each year), and at such other times and places as may be deemed expedient, to examine candidates for the practice of land surveying and issue licenses under seal to those who, after examination shall be regarded as competent; to establish or cause to be established and maintained

in some suitable place or places in each County, true meridian lines in connection with standard United States measures of one hundred feet and parts thereof; to examine and approve such instruments and measures as may be used by the Licensed Surveyors, at such times as may appear necessary; to ordain from time to time such rules and regulations for the practice of surveying as will conduce to uniformity of method, insure the most accurate work, and lead to the fixing of permanent boundary monuments; to cause to be kept in suitable books of record full minutes of the proceedings of the Board.

SEC. 3.—The State Board of Surveyors, when organized as prescribed in and by this Act, shall be invested with all the powers and be required to perform all the duties now exercised and performed by the Board of Property, and shall be subject to all laws now in force applicable or relating thereto; and said Board of Property, as now constituted—consisting of the Attorney-General, Secretary of the Commonwealth and Secretary of Internal Affairs shall be abolished.

SEC. 4.—The Board shall procure a seal to contain the legend —"STATE BOARD OF SURVEYORS, PENNSYLVANIA," and cause the same to be impressed upon all licenses, copies, and other papers or records authenticated in the office thereof.

SEC. 5.—Copies of all records, documents and papers in the office of the Board, when duly sealed and certified by the President, Acting President or duly authorized Clerk of the Board, shall be received in evidence in the several Courts of this Commonwealth in all cases where the original records, documents and papers would be admitted in evidence.

SEC. 6.—From and after the passage of this Act, Licensed Surveyors only shall be eligible for election or appointment as County Surveyors.

SEC. 7.—From and after the first day of January, one thousand eight hundred and eighty-two, it shall be unlawful for any person to practice the profession of land surveying until he shall have passed a successful examination before the State Board of Surveyors and been duly licensed by them. *Provided, however:* That any person who, at the time of the passage of this Act shall have been actually engaged in his profession as a Surveyor for fifteen

or more years, may receive a license without being required to pass a technical examination. Each licensed surveyor shall take and subscribe before one of the Judges of the Court of Common Pleas, an oath or affirmation to perform his duties as a land surveyor with fidelity; which oath or affirmation shall be filed on record in the office of the State Board of Surveyors. Any person violating the provisions of this section shall be liable to a fine of one hundred dollars for each and every offence, to be recovered as debts of like amount are now by law recoverable.

SEC. 8.—It shall be the duty of every Licensed Surveyor to conform to all the rules and regulations which may be adopted from time to time by the said Board for the government of Land Surveyors, and shall submit his instruments and measures to the inspection of the said Board whenever reasonably demanded by them.

SEC. 9.—From and after the first day of January, one thousand eight hundred and eighty-two, in all surveys made within this Commonwealth, fixing the location of County, Township, or property lines, the use of the magnetic needle must be avoided as far as possible, and all measurements in surveys shall be reduced to horizontal measurements, and be made with Improved steel measuring lines, chains or rods, tested by the standard United States measures, or by such other accurate methods as may from time to time be prescribed by the State Board of Surveyors.

SEC. 10.—From and after the first day of January, one thousand eight hundred and eighty-two, all Licensed Surveyors, in marking the corners or angles in surveys of property or roads made by them, shall, after final location, wherever the nature of the ground renders it practicable, use landmarks made of stone, or other imperishable material.

SEC. 11.—Any person who shall knowingly or maliciously alter or remove any stone or other landmark, marking the line of any County, Township, Road, Street or Property, shall be guilty of a misdemeanor, and on conviction, be sentenced to pay a fine of not exceeding five hundred dollars, and to undergo an imprisonment of not exceeding one year.

SEC. 12.—It shall be lawful for any Licensed Surveyor, with or without his assistant or assistants, to enter into or upon the lands

of any person or corportion at any reasonable hour in the performance of his duty as Surveyor.

SEC. 13.—Engineers actually in the employment of any railroad, canal, or other corporation of this Commonwealth, shall not be subject to the provisions of Section Seventh of this Act, in making surveys for the purposes of their respective corporations, excepting the fixing of property lines.

SEC. 14.—Nothing in this Act contained shall be construed to prevent any person from making surveys within the boundary or containing lines of any land for the purpose of landscape gardening, laying out cemetery lots, and the like; nor shall any of the provisions of this Act be construed to impair, alter, appeal, or otherwise affect any existing law providing for the election of Surveyors, and prescribing the duties thereof, in any of the incorporated Cities, Towns or Boroughs in this Commonwealth; but all such officers hereafter chosen shall be selected from among the Licensed Surveyors of the State.

SEC. 15.—Whenever a Licensed Surveyor is required to attend Court, or any other Judical examination, as an expert witness to testify to the accuracy of his work in the location of any disputed lines, he shall be entitled, in addition to mileage, to five dollars per day for the time he has necessarily expended thereby, to be taxed as other costs in the case.

SEC. 16.—The office and records of the State Board of Surveyors shall be kept in the building known as the Department of Internal Affairs.

NOTES AND COMMUNICATIONS.

THE GRANT SELF-CLEANSING WATER FILTER.

REGULAR MEETING, OCTOBER 16th, 1880.—Mr. Linwood O. Towne made a few remarks on the Grant Self-Cleansing Water Filter, showing the same. This filter is made of different sizes to suit single faucets, main pipes for filtering the entire supply of a building, engine boilers, etc.; that for house purposes was alone exhibited. The filter is in two parts, an inner globe and an enclosing case consisting of two hemispherical parts screwed together, the upper of these hemispheres having a screw for attachment to the faucet, the lower one holding the above globe which, by means of pivots and a handle on the outside, may be made to revolve. This inner globe, which is the filter proper, is a single brass casting of peculiar construction; a tube passing through its centre allows of the free passage of water without filtration when desired. At right angles to this tube on the surface of the globe are orifices through which the water in its passage is made to divide into four parts instead of going directly from top to bottom, thus getting the full force of the bone charcoal or other filtering mixture with which the globe is filled. The orifices are provided with fine wire strainers.

Matter having collected on the upper strainer the filter may be reversed without removal from the faucet by means of the handle on the outside, the clean strainer being brought up from below, the first water passing through effectually cleaning the one that was before above.

The readiness with which this filter may be cleansed, and the fact that a free passage of water is furnished when a greater force of water is required than when the water is filtered, are its main advantages.

The *Crocker Filter*, which though similar in general construction, differs in some material points, was also mentioned.

THE CASTING OF THE LARGE ANVIL BLOCK.

REGULAR MEETING, OCTOBER 16th, 1880.—Mr. Charles T. Thompson presented the following description:

Last week I visited Pittsburg to see the casting of the large anvil block for the seventeen ton hammer now being built by William B. Bement & Sons, of Philadelphia, for Park Bros., Black Diamond Steel Works, Pittsburg.

This is, I believe, the largest hammer in this country. Its general dimensions are: Diameter of cylinder 40 in.; stroke 9 ft. 0 in.; diameter of piston-rod 11 in. The ram is of Krupp steel, 6½ ft. long, 46 in. wide and 2½ ft. thick. Dies 32 in. long by 16 in. wide. Weight of falling parts 17 tons. Frame and legs are of wrought iron. The plates, which are from ⅞ in. to 1⅛ in. in thickness, are riveted together with angle iron, which is, generally, 6 in. × 6 in. × ⅞ in. The legs are bolted to frame and bed-plate; all the rest of the work is riveted together. Total weight, excluding anvil block, 190,000 lbs.

In casting the anvil block there were in use five cupolas, four plain cylinders, 54 inches in diameter and one Mackenzie. The spouts were joined together by a

trough of fire bricks, in cast iron frame: these ran into a large receiver, capable of holding 30 tons. There was another reservoir, capable of holding 20 tons, to be used in case of accident to the first. These reservoirs were built of fire brick lined with fire clay. In the largest reservoir there were two openings, so that a large flow of metal could run out without any danger of not being able to plug them up. The anvil block is 12 ft. 8 in. × 10 ft., across the bottom; 10 ft. high, 3½ ft. × 6 ft. across the top, with a recess for the anvil die, the size of which I am sorry to be unable to give. The mould was made so that the top of the anvil block was at the bottom of the mould, so that any dirt or slag could rise to the top, or rather, the bottom of the anvil block, so giving a clean face for the die to rest on. The mould was sunk into the ground, so that the top was slightly below the level of the floor. A large plate of iron had been cast, to build the mould upon. The outside of the mould was the same as in an ordinary loam casting; then, on account of the intense heat, came two layers of fire brick and this was covered by ½ in. of fire clay and then black leaded. The gates were six in number, at different heights, and were about 6 in. × 4 in. They were connected by one slightly smaller, so that the iron would not back up and come out of a higher opening. These gates did not chill up, as it was supposed they would, from the fact of such a quantity of iron being poured each time. There were sixteen vents, about 2 in. square, for taking the gas from the bottom of the mould, but there was very little escape, or rather, formation of gas. Around the outside of the brick mould, about a foot from each side, was a sheet iron case, rivetted together, and between this and the mould sand was rammed, and then on the outside it was rammed up again, so as to make it a firm and secure backing for the mould. To dry the mould, fires were lighted around the brick work, before it was rammed up, and kept burning for about two weeks, and baskets were suspended, filled with coal. While the drying was going on, the mould was covered by sheet iron plates to keep the heat in.

The fires were started in the cupolas at 5.20 A. M.; the blast was turned on at 6 A. M.; at 20 minutes of 7 the first iron was run into reservoir; reservoir was tapped about 7.20 A. M., and last run from reservoir made about 1.30 P. M.; the iron, through all the tappings, running very fluid. The mould, or rather, the casting, after having chilled sufficiently to form a skin, was covered with fine charcoal, and then sand, to a depth of about two feet, and it will be left for four or five months before being uncovered.

NEW METHOD OF HEATING AND PURIFYING FEED-WATER FOR BOILERS.

REGULAR MEETING, NOVEMBER 20th, 1880.—Mr. George S. Strong, introduced by Mr. Chas. T. Thompson, exhibited a number of specimens of different varieties of scale formations in boilers, and drawings of an appliance, made by the I. P. Morris Company of Philadelphia, designed to anticipate the precipitation, in the boiler, of those minerals forming scale, by effecting a chemical and mechanical separation of the minerals from the water before it enters the boiler.

In the development of the steam engine, it becomes necessary to secure the best arrangement for evaporation and the best boilers and boiler appliances, it being well known that the best average steam boilers, under proper management, develop about

double the duty usually obtained under unskillful management. It would seem that greater advancement has been made in the application of steam after evaporation, than in its actual evaporation. From a test made in 1820, it appears that about eighteen pounds of coal per horse-power per hour was used at that time, and that the evaporation was only three pounds of water for each pound of coal, while now, with an automatic cut-off high pressure engine, with an evaporation of eight pounds of water for each pound of coal, not more than three to four pounds of coal per horse-power per hour are required. On some marine engines, as low as two and a half pounds of coal per horse-power per hour have proved sufficient. While there should be an evaporaation of twelve pounds of water to each pound of coal, which has been accomplished in marine boilers, the common evaporation is not over six or seven pounds. The cause of this is, in many cases, the improper construction of boilers to give the best results. In other cases, the water to be employed is of such a character that the best constructed boilers cannot be used. Impure water is a great annoyance and constant source of loss to steam users, and one that is very general. There is scarcely any section of this country or Europe that is not affected by it. All waters contain more or less vegetable and earthy matters in suspension, and most of these have solid matter in solution in greater or less proportion. All these solids are capable of being precipitated by heating the water to a high temperature. That is what takes place in the boiler, and the precipitated salts settle to the bottom, or rest on the sides of the boiler,

FIG. 1.

Formation of scale where an open heater was used and water heated to 190° Fahrenheit. Thickness as bunched, three inches.

and then become hardened into scale. The thickness and solidity of this deposit vary, according to locality, composition of water and management, from 1-64 to three inches. How serious this trouble may become, will appear very clearly from the calculations of Dr. Joseph G. Rogers, who has given the subject careful study. According to this authority, the evil effects of scale are due to the fact that it is relatively a non-conductor of heat. Its conducting power, compared with that of iron, is as 1 to 37.5. Many estimates have been made as to the loss of heat caused by it, some estimating it as high as twenty per cent. for a lime scale of 1-16 in thickness, increasing rapidly wi.h

greater thickness. Another observer has demonstrated that each sixteenth made a difference of fifteen per cent. increase, so that one-fourth makes sixty per cent. loss. The minerals giving the most trouble are, sulphate of lime, carbonate of lime, oxide of iron, magnesia, alumina and silica. The most troublesome and dangerous of these is the sulphate of lime, which results from the combination of oxide of calcium with sulphuric acid. This is precipitated by heat in the form of small crystals, or thin flakes, and in that form floats to where there is least agitation in the boiler and settles, forming a thin white scale, which admits of neither contraction nor expansion. When the scale has attained a thickness of 1-16 in the tubes and sides of the boiler, it breaks off and gathers in bunches on edge (see Fig. 1), sometimes covering several feet and in the form of a cone. In either case the boiler is liable to be BURNED, especially if fired with soft coal. Sulphate of lime is much heavier than water, having a specific gravity of 2.16. The following table shows the amount held in solution at different temperatures from 217° Fahr., according to the experiments of M. Coste, of France:

Temperature.	*Percentage held in solution.*
217°	.500
219°	.477
221°	.432
227°	.395
232°	.355
236°	.310
240°	.267
245°	.226
250°	.183
255°	.140
261°	.097
266°	.060
271°	.023
290°	.000

Another very troublesome mineral is carbonate of lime, composed of carbonic acid, resulting from the decomposition of vegetable or animal matter with lime or oxide of calcium. This is also precipitated by heat in the form of very fine powder or crystals, and it is often found in combination with sulphate of lime. The two combined make a very hard, light gray scale, which also has a tendency to gather in bunches. The combination of these two minerals with mud makes a very hard, thick scale of a dark color (see Fig. 2). This is mostly precipitated at 260° Fahr., and has a specific gravity of about 2.4 as compared with distilled water.

Another of these minerals is oxide of magnesia, which is sometimes known as alkali, and is very similar in its action when heated to carbonate of lime, forming a thin, white powder. It is precipitated at a temperature of 212° Fahr., and has a specific gravity of 2.4. Oxide of iron, composed of brown iron mixed with clay, and other impurities, forms a reddish scale, which is very injurious to boilers, as it tends to start corrosion. It is also precipitated at 212° Fahr., and its specific gravity depends on the amount of earth, but is about five times that of water.

Alumina is sometimes found, and forms a very hard, white scale. It is precipitated at 212° Fahr., and has a specific gravity of 2.56.

Silica is also precipitated by heat at 212° Fahr., and has a specific gravity double that of water.

Another very troublesome and dangerous agent in much of the water found in mining and iron regions, is sulphuric acid, which has a tendency to cause rapid corrosion. When the corrosion is covered with scale, it will sometimes eat very nearly through before it is discovered, frequently destroying iron boiler tubes before they have been in use one year. This is also separated by heat, on account of its specific gravity, which is 1.844, and requires a temperature of at least 260° Fahr. It has been discovered, by careful investigation, that sea or salt water forms a scale composed mostly of carbonate of lime, and that salt alone will not form a scale if proper attention is given to blowing on the surface blow. Most scale formed in the boilers of ocean steamers is composed of lime and silica, with small traces of salt.

FIG. 2.

Formation of scale where a coil heater was used. Thickness three-eighths of an inch. Water heated to 170° Fahrenheit.

The claim made for Strong's Patent Feed-water Heater and Purifier is, that the water is HEATED TO THE PRECIPITATING POINT, causing a CHEMICAL separation. In accomplishing this result, exhaust steam, that would otherwise be wasted, is used up to 208° to 212°, when the temperature is increased to the precipitating point by the use of a live steam coil. The water is then filtered, as a last step, by passing it through wood charcoal, or any other suitable material, for the purpose of causing a complete MECHANICAL separation. The system of brass tubes for the exhaust steam, as shown in lower part of cut, is so arranged as to permit perfect freedom of contraction and expansion, and to cause a rapid and thorough circulation. The water being fed at the side of the heater, near the bottom, comes in contact with the tubes and is heated. The earthy matter is allowed to settle on the bottom, while the warm water rises. When the water has reached the top of the tubes, it obtains a temperature of from 208° to 212° Fahr., according to the point of cut-off and pressure of steam. This temperature is sufficient to cause precipitation of most mineral deposits, except the sulphates

and carbonates. When these are present in water, the coil shown on the central portion of the cut, through which live steam circulates, causes a rise of temperature almost equal to that in the boiler, after which the water is passed up through a filter composed of packed charcoal, held between cast iron plates well fastened together, leaving a deposit of minerals in the lower portion of the filter. The water then passes out at the side of the dome into the steam space of the boiler. The dome is shaped to gather any scum that might arise at the highest point, from which it is pumped back to the bottom—by the inrushing jet of feed-water—by the ejector connecting the circulating pipe with the bottom.

FIG. 3.

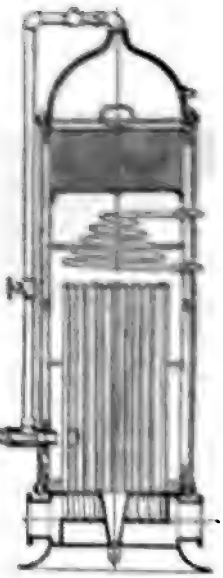
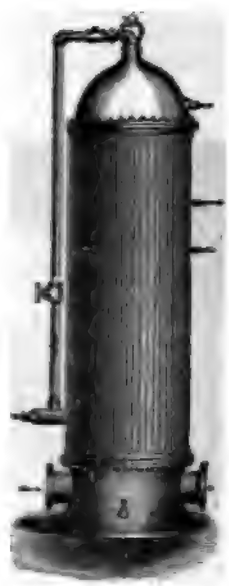


FIG. 4.



The heater should be blown out, when in use, every three to ten hours, according to condition of water; when this is done, the action of the water is reversed. The live steam from the boiler is blown back, thoroughly cleansing the filter, at intervals of three to ten hours, and blowing all the sediment from the bottom. This will keep the filter clean, and prevent the necessity of renewing the charcoal oftener than once in sixty to ninety days. This cleaning process is easily accomplished by removing the brass nuts in the dome flange, lifting off the dome, and taking out the filter, when it can be repacked or replaced with one held in readiness for the purpose, in which case not more than thirty minutes are required. When the dome and filter are off, a hose can be used to wash out the heater from the top, which is equally necessary.

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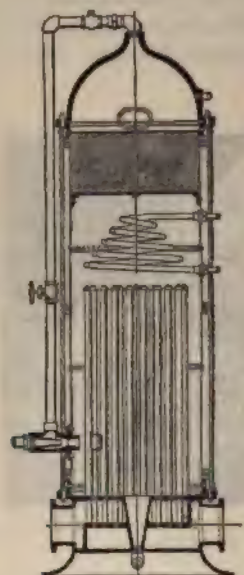
FIG. 3.



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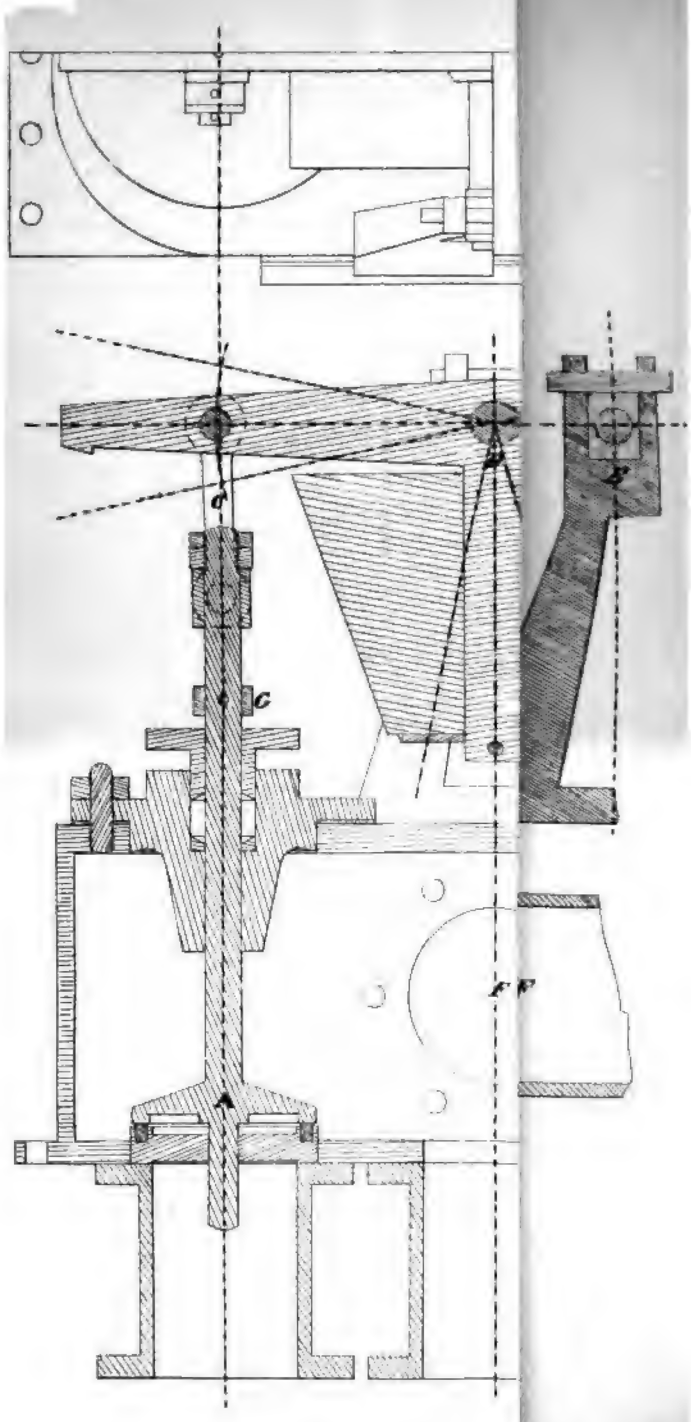
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PERCENTAGE OF SAVING OF FUEL IN STEAM BOILERS BY HEATING FEED-WATER.

We take the following Table, showing comparison with the results derived from cold water feed, from a recent publication by Babcock & Wilcox, Engineers, New York.

(Steam at 60 lbs.).

FINAL TEMPERATURE.	INITIAL TEMPERATURE OF WATER.												
	32°	40°	50°	60°	70°	80°	90°	100°	120°	140°	160°	180°	200°
60°	2 39	1.71	0.86	0									
80	4.09	3.43	2.59	1.74	0.88	0							
100	5.79	5.14	4.32	3.49	2.64	1.77	0.90	0					
120	7.50	6.85	6.05	5.23	4.40	3.55	2 68	1.80	0				
140	9.20	8.57	7.77	6.97	6.15	5.32	4.47	3.61	1.84	0			
160	10.90	10.28	9.50	8.72	7.91	7.09	6.26	5.42	3.67	1.87	0		
180	12.60	12.00	11.23	10.46	9.68	8.87	8.06	7.23	5.52	3.75	1 91		
200	14.30	13.71	13.00	12.20	11.43	10.65	9.85	9.03	7.36	5.62	3.82	1.96	0
220	16.00	15.42	14.70	14.00	13.19	12.33	11.64	10.84	9.20	7.50	5.73	3.93	1.98
240	17.79	17.13	16.42	15.69	14.96	14.20	13.43	12.65	11.05	9.37	7.64	5.90	3.97
260	19.40	18.85	18.15	17.44	16.71	15.97	15.22	14.45	11.88	11.24	9.56	7.86	5.96
280	21.10	20.56	19.87	19.18	18.47	17.75	17.01	16.26	14.72	13.02	11.46	9.73	7.94
3 0	22.88	22.27	21.61	20.92	20.23	19.52	18.81	18.07	16.49	14.99	13.37	11.70	9.93

THE VALUE OF THE AUTOMATIC VALVE ARRANGEMENTS FOR THE BILGE PUMPS OF SHIPS AND ESPECIALLY FOR STEAMERS.

REGULAR MEETING, DECEMBER 18TH, 1880.—Mr. J. J. de Kinder presented the following:—

When a vessel is moving on an even keel, or nearly so, there is no trouble in keeping her bilges free of water; or even if she has a strong list, providing she keeps that list, or in other words, so long as the water in the bilges is, comparatively speaking, in rest, a good bilge pump will not fail to draw and throw water.

But what if the vessel rolls heavily?

Whatever water there is in the bilges will fly violently from side to side; especially is such the case in a steamer constructed with water ballast tanks, as nearly all ocean steamers are. Generally the stoke hold floors are from 18 to 24 inches above the flat surface of the ballast tank.

Then a small quantity of water which would measure but a few inches amidships with the vessel gliding along on an even keel, will leap over into the wings, thus accumulating suddenly in a smaller space and seeming a much larger volume.

It suddenly rushes up through the joints of the stokehold floors, often bursting up the plates or even the coal bunker floors, and, on the return roll of the vessel, whatever volume of water has gathered on top of the floor will rush over to the other side, carrying coal and ashes into the bilges and impairing the action of the bilge pumps by continually choking the valves, thus reducing more and more their efficiency to cope with the water, which often obtains the upper hand, and with what results?

The boilers are continually being washed, cargo is often damaged, etc., and the engine department, harassed and obliged to give its entire attention to this water trouble,

is prevented from doing justice to the engines and vessel, apart from the repeated trouble and expense of cleaning out the bilges. In many cases the water puts out the fires, with results which steamship men know to their loss and sorrow.

The only sure preventive against this is in having some arrangement which will insure to the bilge pumps a steady and unbroken action at all times independent of the position of the vessel, thus preventing water from showing itself at any time on the stokehold floors. What means are there at present employed to accomplish this?

Generally a steamer has two connected bilge pumps—a suction pipe in either wing; consequently only one pump at one time plies upon the low side where the water accumulates, while the pump communicating with the suction pipe in the opposite wing is doing nothing and on the return roll it takes some time before that pump throws water—it having to fill the entire length of the suction pipe before it will throw again.

I have designed and patented an automatic valve arrangement, simple and compact, which I feel confident will ensure that constant and uninterrupted pump action so much desired—no matter how hard a vessel rolls.

In the accompanying drawing, the two valves *A* and *B* are connected by the links *C* to the lever *D*.

This lever made of wrought iron is forged in the form of a *T* and is hung by means of a pin in the brackets *E* and *E*, while the centre arm carries a heavy weight. One valve controls the "port wing" suction, the other the "starboard wing" suction.

The bilge pump or pumps are connected with this valve box by means of the pipe *F*.

When the vessel is in a perfectly upright position both valves are closed, but as soon as she passes her centre, for instance to port, the port valve will immediately lift, while the starboard valve remains closed. (The links *C* are attached to a sleeve which moves freely on the rod, thus, while one valve is lifted, the sleeve on the opposite side slides down over the valve rod, until it meets the collar *G* which determines the height of the lift of the opposite valve; thus, in this plan, the valve is full open for an angle of 6° already.) The pump or pumps will consequently immediately draw from the lower side through the open valve, or from that side where the water lies, and will continue to do so until the vessel on the return roll again passes her centre when the port valve immediately closes, while the starboard one at the same time lifts and the action of the pumps is brought at once to bear on the now lowest side. In fact the pumps simply follow the water from side to side, just as if the suction pipe rolled backwards and forwards with it.

It is apparent that with this arrangement only one bilge pump will be thus keeping up a steady uninterrupted action and do more execution than two or even three pumps in the ordinary method. The valve box can be fitted with three suction pipes, one in the centre communicating with the amidships so that, in fine weat. er, the balancing valves, being closed, are kept closed by arresting the motion of the pendulum and the pumps are free to draw from this centre suction pipe, which, in turn, can be closed by a cock or stop valve.

For sailing vessels, especially those carrying grain, this arrangement seems to offer a decided superiority over the present arrangement.

BUILDING A HOUSE ON A SAND HILL.

REGULAR MEETING, DECEMBER, 18TH, 1880.—Mr. J. J. de Kinder also presented the following:

As I am not aware that it has ever before been attempted in the United States to build a house on the very top of a lofty sand hill, exposed to all winds and weather, while simply depending upon, or rather by simply making the loose sand the agent to keep it firmly secured in its seat, I think a few words upon the construction of a signal station which I have just finished for the Maritime Exchange of this city, on top of the highest sand hill at Cape Henlopen, may be of interest to some.

The signal station mentioned will serve to report, the arrival at and departure from the Breakwater of all passing vessels, to the Philadelphia Maritime Exchange, by means of the Western Union Telegraph lines which connect it with this city.

In the first place, it was necessary that the observer stationed in the building should have a clear and unobstructed view of the seaward horizon from south to north, that is, seaward of the coast line.

To obtain this it was necessary to erect the building on top of a hill, which rises some 80 feet above the level of the sea.

But the building thus necessarily becomes exposed to every gale that sweeps that part of our coast, while it is absolutely required that it shall stand firmly planted in such a way that even a hurricane shall not shake it or make it tremble, as that would affect the sight of the telescope in the observatory.

The usual mode of securing is by building a foundation of screw piles or of heavy timbers sunk into the sand; the latter mode, however, has this disadvantage, that if the wind shifts the sand away from around the foundation, it becomes undermined and its effect is thus destroyed.

In order to be independent of all this, I designed what I consider a cheap and, at the same time, an effective anchorage for the building in the following manner.

The building is of wood entirely; it has a cellar, above which two rooms, one above the other, and the whole surmounted by the observatory proper.

First, the ground sill is a square of 20 feet, made of yellow pine sticks, mortised together and pinned with stout trunnels.

The sill of the observatory is made likewise of heavy timbers, 12 feet long. The two sills are joined together by four stout yellow pine corner-posts, which in turn are mortised into both sills. The posts are 26 feet in length. Five feet above the lower sill is the sill which supports the floor of the first room.

Ten feet above this is the sill which supports the upper room.

Both these sills again are mortised into the corner-posts.

This structure is sheathed outside with German siding, inside with rough boards covered with felt, and again by tongued and grooved yellow pine boards.

The observatory proper, octagon in shape, is securely mortised into the top sill and is covered with a corrugated iron roof, conical in shape.

The cellar is floored with 3 inch wood, and boarded all around on the inside of the posts.

I first dug a pit in the sand, about 6 feet deep and fully 20 feet wide on the bottom, I then laid the ground or cellar sill on this bottom, and built the structure; thus the whole depth of the cellar is sunk below the top of the hill, or the level of the sand.

I then filled the cellar up soli l with sand, and packed it solid all around the outside also; consequently the building is anchored in its place by the load in the cellar, some 100 tons in weight.

I carried three heavy joists (part of the joists which carry the first floor) through on one side of the building, and on these the kitchen was built, so that this is also independent of the position of the sand under it. Since the construction of the station we have had some very severe blows, yet there is no more tremble in the building than if built of stone on a rock.

A few feet from the building stands a signal post or mast, 1C0 feet high, which carries a 5 foot ball of rattan covered with canvas; the ball is made to slide on the mast, and is used to answer signals from vessels by raising and dropping it. As it would, in my opinion, be a rather dangerous thing to simply place the mast in the sand—no matter how deep, I sank a well into the sand hill.

This well is made of pine, 20 feet deep and 8 feet square. The mast is placed in the centre of the well and is braced, from the corners of the pine box, by some 20 stout braces, and the well afterwards filled and tightly packed with sand inside and outside, so that, like the house, to blow it over would necessitate moving of a tremendous weight of sand with it.

A SYSTEM OF TOPOGRAPHICAL MAPPING OF MINES.

REGULAR MEETING, JANUARY 15th, 1881.—Mr. Chas. A. Ashburner explained in brief the system which he had devised for mapping the anthracite coal fields and of representing in a practical way the topography of the mines. It is proposed to construct underground contour curve maps of the mines, the curves to be 50 feet vertically apart. After the area which is worked out and under development shall have been contoured, it is planned to continue the contours, from the best information available, across the areas as yet unworked. A finished map of portions of the Second Basin in the vicinity of Mahanoy City and Shenandoah, Schuylkill County, was exhibited, constructed to a scale of 800 feet to 1 inch. The information which was represented on this map was as follows:

1. Elevation of the outcrop of the Mammoth coal bed.
2. Degree and direction of dip of the bed.
3. Strike of the bed.
4. The depth of the Mammoth basins.
5. The areas of the Mammoth bed worked out and under development.
6. The gangways, slopes, airways, adits and shafts belonging to all the coal beds above and below the Mammoth bed. From these facts the areas of each bed worked out and under development may be readily estimated.

This map was published by Mr. Julius Bien, of New York, and although it was loaded with a large mass of facts, everything was clear and distinct.

One of the most practical and important applications of the method proposed by Mr. Ashburner is the means which it affords for the accurate estimation of the area of the coal beds under any given tract, and consequently its coal tonnage. It is readily perceived that when the contoured area of the coal bed is flattened or ironed out into a horizontal plane, the actual area of the bed, irrespective of its dips, may be determined.

MINUTES OF MEETINGS.

OF THE CLUB.

SEPTEMBER 18TH, 1880.—Special Meeting.—President Frederic Graff in the chair. Ten members present.

This meeting had been called for the purpose of receiving all pending nominations for membership, and after having transacted this business the Club adjourned.

OCTOBER 2D, 1880.—Business Meeting.—Vice-President Percival Roberts, Jr., in the chair. Seventeen members present.

Messrs. Mucklé and Darrach were appointed tellers and the following members were elected, viz.: Messrs. Eugene Borda, Franklin N. Corlies, Jesse Lightfoot, James M. Stewart, Joseph L. Ferrell, David Reeves, T. Carpenter Smith, Col. Wm. Ludlow, and Col. James Worrall.

Mr. Sam'l L. Smedley, of the Committee on Land Surveying, stated that they had held a number of meetings and had determined to hold a convention at Harrisburg on October 27th, to which all the land surveyors in the State were invited.

The resignation of Gen. W. F. Reynolds as an active member of the Club, was accepted.

OCTOBER 16TH, 1880.—Regular Meeting.—President Frederic Graff in the chair. Sixteen members present.

Mr. Linwood O. Towne exhibited and described the Grant Self-cleansing Water Filter.

Mr. Chas. T. Thompson read a paper on the casting of the large anvil block recently cast for Park Bros., Pittsburgh, and exhibited and explained drawings for a large pumping engine, designed by and now being built at the shops of the I. P. Morris Company, for the Calumet and Hecla Mining Co.

Mr. J. Milton Titlow called the attention of the members of the Club, especially those interested in street pavements and passenger railways, to the work now being done on Sixth Street, between Chestnut and Walnut Streets, Philadelphia. The Fifth

and Sixth Sts. Passenger Railway Company is now renewing the tracks, laid 23 years ago, the yellow pine stringers of which are still in very good condition, the fibre being strong and tenacious. In doing this work they have cut longitudinally the specimen of asphaltum pavement, laid upon that square about five years ago, showing the hydraulic base, cushion coat and top coat or wearing surface of compressed asphaltum. This pavement is the same as those recently laid in the City of Washington.

October 16th, 1880.—A Special Business Meeting was called to order, after the regular meeting, to ballot upon the following, who were elected active members of the Club: Messrs. Strickland Kneass, Jr., John J. Hoopes, and Chas. A. Rutter.

November 6th, 1880.—Regular Meeting.—President Graff in the chair. Fourteen members present.

Mr. David Townsend presented notes on the etching of cold punched nuts, and exhibited specimens of the work.

He also exhibited specimens of a new fuel, made from coal tar, but stated that his experiments therewith had shown poor results.

He also exhibited a specimen of cast iron, which had resisted a tensile strain of 30,000 pounds, whereupon an interesting discussion ensued by Messrs. See, Neilson, and P. Roberts, Jr., upon the shapes of test pieces of iron which had been used, and the desirability of establishing and adhering to uniform shapes and equal sectional areas.

November 20th, 1880.—Regular Meeting.—Vice-President P. Roberts, Jr., in the chair. Twenty members and one visitor present.

A description of the Fontaine Locomotive Engine by Mr. John T. Boyd was read by the Corresponding Secretary.

By invitation of the Chairman of the Committee on Information, Mr. Geo. S. Strong described his feed water heater, an apparatus designed to prevent the formation of boiler-scale by the precipitation by heat of such impurities as could not be removed by filtration. Working drawings were shown and ex-

plained. A vote of thanks was offered to Mr. Strong for his paper, and to Mr. A. R. Roberts for his presentation to the Club of the Goniometer used on the location of the Alleghany Portage Railroad.

DECEMBER 4TH, 1880.—Business Meeting.—President Graff in the chair. Twenty-four members present.

The following were elected active members of the Club: Messrs. Joseph Johnson, Thos. H. Graham, David Peelor, Geo. W. Hancock, and Chas. C. Wentworth.

The following amendment to Art. IV, Sec. 2, of the Constitution was submitted by Messrs. Howard Murphy, Wilfred Lewis, J. H. Dye, Geo. Burnham, Jr., and Lewis M. Haupt:—

In the second clause after the words "of this article" to strike out the word "*and*," and after the words "interests of the Club" to insert the words "*and who will, as often as may be.*" Also, after the second clause to insert the words, "*They shall be subdivided into two classes, viz.: Resident and Non-Resident Members. Non-Resident Members shall be those who shall reside for one entire fiscal year or more at a distance of at least fifty* (50) *miles from Philadelphia, and, during such residence, they shall be entitled to such reduction in annual dues as shall be provided for in the By-Laws, but shall be deprived thereby of no Club privileges.*"

Upon motion, the report of the Committee on Land Surveying was ordered to be printed in the Proceedings.

DECEMBER 18TH, 1880.—Regular Meeting.—President Graff in the chair. Twenty-one members present.

Mr. J. J. de Kinder read a paper on the Value of the Automatic Valve for the Bilge Pumps of Ships, Especially for Steamers, and, also, a paper upon the Method of Construction of a Signal Station on a Sand Hill at Cape Henlopen.

Prof. L. M. Haupt presented some preliminary notes of a paper upon Intercommunications in Philadelphia, suggesting a tunnel of about three miles to reduce the distance and grade on the Philadelphia and Reading R. R. between the Falls Bridge and Port Richmond.

Mr. A. R. Roberts questioned its desirability and gave the history of some of our railroad locations.

Some matters of historical interest in Philadelphia engineering were discussed by Messrs. Haupt, Roberts and Murphy, and the collection of such data for the journal was urged.

President Graff, in presenting to the library a volume from the late Henry R. Worthington, announced with much feeling, the late sudden death of the donor, paying the highest tribute to his social and domestic qualities, and the great benefits he had conferred upon engineering science, particularly in hydraulic engineering, by his inventions. He was the first, it is believed, to apply direct acting, now called "donkey" feed pumps, for supplying the boilers, whilst the main engine is not in motion. For water-works of large capacity, his was the first direct acting pump so employed. His water meter and pressure pumps for hydraulic lifts, etc., are now almost universally used in steel works and on the successful pipe lines in the oil regions. As early as 1840, Mr. Worthington began his improvements in pumps, having noticed their special necessity for steam canal navigation, when hand pumps had to be used by the boats lying-to, awaiting lockage. His invention, then began, was carried to such successful completion that the great John Ericsson speaks of his hydraulic engine as "one of the greatest triumphs of modern engineering."

JANUARY 8TH, 1881.—Third Annual Meeting. President Graff in the chair. Thirty-four members and two visitors present. The Annual Reports of the Recording and Corresponding Secretaries and of the Treasurer were presented.

Mr. Frederic Graff, the retiring President, delivered the Annual Address.

The tellers of the annual election, Messrs. Haupt and Mucklé, reported the following gentlemen as elected officers for the year 1881:

President.—Strickland Kneass.

Vice-President.—Henry G. Morris.

Recording Secretary.—Wilfred Lewis.

Corresponding Secretary.—Howard Murphy.

Treasurer.—A. R. Roberts.

Board of Directors.—Frederic Graff, Rudolph Hering, J. J. de Kinder, T. M. Cleemann and George Burnham, Jr.

The proposed amendments to Article IV, Sec. 2, of the Constitution (page 189) were carried by a vote of 76 to 10.

Mr. Frederic Graff, retiring President, then introduced Mr. Strickland Kneass, President elect, who, after making an appropriate address, assumed the duties of his office. Upon motion, the Annual Meeting adjourned, and a business meeting was called to order. Messrs. Leon T. Merry and T. Earl Collins were elected active members of the Club. Mr. Frederic Graff offered the following, which was adopted:

"Resolved.—That the Engineers' Club of Philadelphia extend to the American Institute of Mining Engineers, the free use of the Club Rooms, during the Annual Session of the Institute, to be held in this city Feb. 15th to 18th."

The resignation of Mr. Harold A. Freeman, as an active member, was accepted.

The following amendment was offered to Article X, of the By-Laws, by Messrs. de Kinder, Haupt and Ashburner:

"That the Article be amended so as to read after the word "Directors" on the 6th line, "*and he shall receive an annual salary, the amount of which shall be determined by the Board of Directors.*"

JANUARY 15TH, 1881.—Regular Meeting; President Kneass in the chair; twenty-six members and three visitors present.

Upon the announcement of the action of the Board of Directors, directing the Corresponding Secretary to endeavor to obtain the consent of Mr. Frederic Graff to the insertion of his portrait, as Past President, in the next number of the Proceedings, an informal vote was taken and the action of the Board unanimously endorsed.

Mr. Chas. A. Ashburner read papers on the Progress of the Second Geological Survey of Pennsylvania and the Topographical Mapping of Mines, and exhibited specimens of the crude and refined petroleums of Baku, Galicia and other European fields, recently received through Hon. Lewis Emery.

He also read a paper, by Col. Jas. Worrall, upon the methods which have been proposed for ship crossings on the Isthmus.

Mr. T. M. Cleemann read a paper on the Strength of Wrought Iron Columns, showing that the accepted formula of Rankine and Gordon give imperfect results, and urging the necessity of

further experiments on various shapes, in order to complete it and render it more exact.

Prof. L. M. Haupt read a paper on Inter-communication in Cities, showing the great value of increased facilities of travel, and applied them specially to Philadelphia. The number of persons using the horse cars during the last year was about one hundred millions, and the value of a saving of one mile in distance and its equivalent in *time* and *power*, was computed upon this basis, with some surprising results. The paper was limited to a consideration of the street system only—the railroad system being reserved for the future. The paper contained some suggestions as to proposed improvements.

Mr. Henry G. Morris exhibited a photograph of a machine designed by Mr. Wm. S. Auchincloss, which, it is claimed, will solve problems in alligation, direct and inverse proportion, right-angled triangles, circles, ellipses, square root, speed of shafting, diam. of pulleys, etc.

FEBRUARY 5TH, 1881.—Special Business Meeting. President Kneass in the chair. Twenty-three members present.

Mr. Thomas U. Walter was elected an Honorary Member of the Club. Messrs. D. H. Shedaker, Russel Thayer, Wm. P. Osler, Henry S. Munroe, James R. McClure, Joseph Mercer, Wm. Henry Baldwin and N. Allen Stockton, were elected Active Members. Upon motion of Prof. L. M. Haupt, the meeting officially and unanimously endorsed the action of the Board of Directors and the informal action of the Club, with regard to the insertion in the Proceedings of the phototype of Past President Frederic Graff, and ordered the appointment of a committee of two members of the Board and two of the Club, to wait upon him and ask for his consent.

An invitation from the Resident Members of the American Institute of Mining Engineers to attend their Musical Reception at the Academy of Fine Arts on February 16th, was read and accepted with thanks.

Upon motion, the Board were requested to employ a clerk to be constantly present in the rooms during the session of the American Institute of Mining Engineers.

A bill for expenses of Committee on Land Surveying was presented and ordered to be paid.

The proposed amendment to Article X, of the By-Laws (page 191) was, upon ballot, unanimously adopted.

The following amendment was proposed to Article XV, of the By-Laws, by Messrs. Haupt, Lewis and H. G. Morris: To strike out the opening sentence and insert in lieu thereof the following: *The annual dues of Resident Members shall be* $7.50 *and of Non-resident Members* $5.00, *payable February* 1*st, and the initiation fee shall be* $5.00.

Prof. L. M. Haupt continued his paper on Intercommunications in Cities, considering the railroad system.

A letter from Mr. John T. Boyd was read giving the result of further experiments with the Fontaine Locomotive.

FEBRUARY 19TH, 1881.—Regular Meeting. Vice-President Henry G. Morris in the chair. Twenty-five members and two visitors present.

Prof. L. M. Haupt read the proof sheets of a paper by Gen. Herman Haupt, upon the Meigs Elevated Railroad. Certain advantages over other systems were claimed. A general discussion followed.

OF THE BOARD OF DIRECTORS.

OCTOBER 9TH, 1880.—Special Meeting. The Corresponding Secretary was instructed to acknowledge the invitation to the Club, from the U. S. Association of Charcoal Iron Workers, to attend their Annual Meeting and excursions, Harrisburg, October 19th to 22d, 1880.

This meeting was called for the purpose of considering the participation of the Club in the Joint Publication Scheme. The past correspondence upon the subject was reviewed and, after discussion, it was decided that the Corresponding Secretary should inform Mr. A. M. Wellington, in whose charge the matter had been, that the printing of our present volume being already under contract, we would decline to take further action in the matter at present.

OCTOBER 16TH, 1880.—Monthly Meeting. Sundry bills approved.

DECEMBER 4TH, 1880.—Special Meeting. Nominations for membership reported favorably and sundry bills approved. The Corresponding Secretary was requested to remind Corresponding Members that they are expected to contribute articles to the journal. Messrs. Haupt and Mucklé were appointed tellers to conduct the annual election.

DECEMBER 18TH, 1880.—Monthly Meeting.

Nominations for membership reported favorably. Sundry bills were approved.

The price of Vol. II, No. 1, Proceedings, was fixed at $1.

It was decided to fix 300 pages, more or less, as the limit of our future volumes.

It was ordered that advertisements be invited at rates to be determined by the Committee on Publication, and not to occupy more than 16 pages of the Proceedings.

The Corresponding Secretary was directed to invite subscriptions to the Proceedings at a minimum price of $5 per volume.

JANUARY 15TH, 1881.—Monthly Meeting. The Standing Committees for the year were announced as follows:

Finance.—Frederic Graff and J. J. de Kinder.

Membership.—J. J. de Kinder and Geo. Burnham, Jr.

Publication.—Rudolph Hering and Geo. Burnham, Jr.

Library.—T. M. Cleemann and Frederic Graff.

The question of increasing the edition of the Proceedings to 800 copies was referred to the Committee on Publication with power to act. Sundry bills were approved.

It was unanimously resolved that Mr. Frederic Graff, Past President, be requested to allow the insertion of his portrait in the next number of the Proceedings, wherein his Annual Address will be published.

FEBRUARY 5TH, 1881.—Special Meeting. Nominations for membership reported favorably and sundry bills approved. Bill

from Committee on Land Surveying for expenses, was reported to Business Meeting of the Club.

FEBRUARY 19TH, 1881.—Monthly Meeting. Nominations for membership reported favorably and sundry bills approved.

The salary of the Corresponding Secretary was fixed, for the present year, at $600, with the understanding that he should perform the duties of the Recording Secretary and Treasurer, if required.

CONTRIBUTIONS TO THE LIBRARY.

FROM SEPTEMBER 1ST, 1880, TO APRIL 9TH, 1881.

From the INSTITUTION of CIVIL ENGINEERS. MR. JAMES FORREST, Sec'y, London.

Douglass—The Seven Stones Light Vessel.

Baker—The Practical Strength of Beams.

The Kandahar Railway.

Hayter—The Amsterdam Ship Canal.

Hedges—Principal Systems of Electric Light in Use in England and in the United States.

Scott and Redgrave, Bernays and Grant—Portland Cement.

Squire, Whitley and Copperthwaite—Earthwork Slips.

Thompson—Light Draught Steel P. S. "Terranorra" for Ocean and River Navigation.

Shaw—Small Motive Power.

Abstracts of Papers in Foreign Transactions and Periodicals—Vol. LXII. Session 1879–80. Part 4.

Churchward—The Monte Penna Wire Ropeway.

Mackinnon—The Sandy Island Lighthouse, Antigua, West Indies.

Unwin—The Co-efficient of Air Flowing in Long Pipes.

Walker—Machinery for Steel Making by the Bessemer and Siemens Processes.

Bovey—Cribwork in Canada.

Sandeman—The River Weaver Navigation.

Annual Report of the Council, Dec. 21st, 1880.

Address of James Abernethy, Esq., F.R.S.E., Presdt. of Inst. C. E., Jan. 11th, 1881.

Boswell—Dredging and Other Plant Employed at the Quebec Harbour Works.

Weyrauch—The Ultimate Working Strength of Materials.

Abstracts of Papers in Foreign Transactions and Periodicals—Vol. LXIII. Session 1880–81. Part 1.

Seyrig—The Different Modes of Erecting Iron Bridges.

Maxwell and Mosse—New Zealand and Ceylon Government Railways.

From the SOCIETY of ARTS, London.

Journal—Weekly.

From the AERONAUTICAL SOCIETY of GREAT BRITAIN.

MR. FRED. W. BREAREY, Sec'y, London.

14th Annual Report for 1879.

From the INSTITUTION of CIVIL ENGINEERS of IRELAND, Dublin.

Transactions—42d, 43d and 44th Sessions, to May, 1879, Vol. XII.

From the SOCIETY of CIVIL ENGINEERS, Paris.

M. HUSQUIN DE RHÉVILLE, Sec'y.

Mémoires—July, Aug., Sept., Oct., Nov. and Dec., 1880; Jan., 1881.

From L'ADMINISTRATION DES PONTS ET CHAUSSEES.

M. DUNOD, Editor, Paris.

Annales—Sept., Oct., Nov., 1880; Jan. and Feb., 1881.

Aucoc—Les Tarifs des Chemins de Fer et L'Autorité de L'Etat.

Personnel—1881.

From the AUSTRIAN SOCIETY of ENGINEERS and ARCHITECTS.
MR. JOSEF MELAN, Editor.

Wochenschrift—
Zeitschrift—Parts VIII, IX, X, XI, and XII, 1880; Part I, 1881.

From the SAXONIAN SOCIETY of ENGINEERS and ARCHITECTS, Leipzig.
Proceedings—1st half 1880.

From the IMPERIAL TECHNOLOGICAL SOCIETY, St. Petersburg.
Transactions—Parts 4 and 5, 1880.

From the SWEDISH SOCIETY of CIVIL ENGINEERS.
MR. C. A. ANGSTRÖM, Sec'y, Stockholm.
Proceedings—Fjerde Häftet, Femte Häftet, Sjette Häftet, 1880.

From the PORTUGESE SOCIETY of CIVIL ENGINEERS.
MR. A. DIRECCAO, Sec'y.
Proceedings—Feb., Sept. and Oct., 1880.

From the EDITORS AND PROPRIETORS, MESS. A. A. C. NEVES and F. L. T. C. DA SILVA, Lisbon, Portugal.
O Constructor. First Series, Nos. 1 to 12 inclusive, 1880. Second Series, No. 1, 1881.

From the ARGENTINE SCIENTIFIC SOCIETY.
D. EDUARDO AGUIRRE, Sec'y, Buenos Ayres.
Anales—Aug., Oct., Nov., Dec., 1880; Jan., 1881.
Berg—La Vida y Costumbres de los Termitos.

From the AMERICAN SOCIETY of CIVIL ENGINEERS.
MR. JOHN BOGART, Sec'y, New York.
Transactions—Sept., Oct., Nov., Dec., 1880; Jan., Feb., 1881.
Index to Library—Part 1. Railroads, Oct., 1880.
Revision of List of Members to Feb. 1st 1881.

om the AMERICAN INSTITUTE of MINING ENGINEERS.
DR. THOS. M. DROWN, Sec'y, Easton, Pa.
Kerr—The Mica Veins of North Carolina.
Maynard—Remarks on a Gold Specimen from California.
Munroe—The Losses in Copper Dressing at Lake Superior.
Kerr—The Gold Gravels of North Carolina.—Their Structure and Origin.
Raymond—A Glossary of Mining and Metallurgical Terms.
Egleston—The Manufacture of Charcoal in Kilns.
Kimball—A Flux for Rolling Mill Cinder and Silicious Iron Ores in the Blast Furnace.
Prime—Supplement I. to a Catalogue of Official Reports upon Geological Surveys of the United States and Territories, and of British North America.
Proceedings of the Lake Superior Meeting, Aug., 1880.
Irving—On Mineral Resources of Wisconsin.
Kimball—On the Self-Fluxing Properties of Chateaugay Magnetite, from Clinton County, N. Y., and its Treatment in the Blast Furnace.
Frazer—Some Copper Deposits of Carroll County, Maryland.
Drown and Shimer—The Determination of Silicon and Titanium in Pig Iron and Steel.
Barnes—A Comparison of Certain Forms of Ports for Steel Melting Furnaces.
Rolker—The Silver Sandstone District of Utah.
Birkinbine—A Short Blast at the Warwick Furnace, Pennsylvania.
Witherbee—Notes on Two Scaffolds at the Cedar Point Furnace.
Witherow—Removing Scaffolds in Blast Furnaces.
Egleston—The American Bloomery Process for Making Iron Direct from the Ore.
Herrick—The Eighty Ton Steam Hammer at Creusot.
Munroe—On the Weight, Fall and Speed of Stamps.
Drown—The Determination of Sulphur in Sulphides and in Coal and Coke.
Sandberg—On Rail Specifications and Rail Inspection in Europe.
Rothwell—The Cost of Milling Silver Ores in Utah and Nevada.
King—The Chemical Reactions in the Bessemer Process, the Charge Containing but a Small Percentage of Manganese.
Transactions—Vol. VIII. May, 1879, to Feb., 1880.
Dudley—The Wearing Power of Steel Rails in Relation to Their Chemical Composition and Physical Properties.

From the AMERICAN IRON AND STEEL ASSOCIATION.
MR. JAMES M. SWANK, Sec'y, Philadelphia.
Bulletin—Weekly.

From the UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS.
MR. JOHN BIRKINBINE, Sec'y, Philadelphia.
Journal—No. 1. April, 1880 (back number, 2 copies), Nov., 1880; Jan., 1881.

From the PI ETA SCIENTIFIC SOCIETY.
MR. W. H. BREITHAUPT, Sec'y, Troy, N. Y.
Papers—Vol. II, No. 1. 1881 (2 copies).

From the WESTERN SOCIETY of ENGINEERS.

Proceedings of 120th Regular Meeting, held Feb. 1st and 3d, 1881—Discussion of Articles of Association of American Engineering Societies. 6 copies.

Proceedings—Vol. V, 1879–80. Bound.

From the BOSTON SOCIETY of CIVIL ENGINEERS.

MR. S. E. TINKHAM, Sec'y.

Records of Meetings—June, Sept., Oct., Nov., Dec., 1880; Jan., Feb., 1881.

From the ENGINEERS' CLUB of CLEVELAND.

Goodwin—The Panama Ship Canal and Inter-Oceanic Ship Railway Projects.

From the ENGINEERS' SOCIETY of WESTERN PENNSYLVANIA.

MR. J. H. HARLOW, Sec'y, Pittsburgh.

Mahan—Constitution of Earths and Slips in Clayey Soils.

Kirk—Blasting.

Williams—The Danks Puddling Furnace.

Reese—The Basic Dephosphorizing Process; What It Is and What May Be Expected From It.

Discussion.

Mahan—Dam of the Montaubry Reservoir.

Annual Reports, Jan. 18th, 1881.

From the BOSTON PUBLIC LIBRARY.

MR. MELLEN CHAMBERLAIN, Librarian.

Bulletin—Jan., 1881.

From the AMERICAN PHILOSOPHICAL SOCIETY, Philadelphia.

MR. J. P. LESLEY, Sec'y.

Proceedings—March 15th, and March to Dec., 1880.

List of Members.

From the PHILADELPHIA SOCIAL SCIENCE ASSOCIATION.

Leland—Industrial and Decorative Art in Public Schools, 1880.

Rosengarten—Penal and Reformatory Institutions.

Sulzberger—Nominations for Public Office.

From the FRANKLIN INSTITUTE, Phila.

DR. ISAAC NORRIS, Sec'y.

Journal—Sept., Oct., Nov., Dec., 1880; Jan., Feb., Mar., 1881.

Supplement to March, 1881. Plates of

Dudley—Wearing Power of Steel Rails.

From MR. ALFRED R. C. SELWYN, Director of the Geological Survey of Canada.

Map to Accompany Report of Progress, 1877–78.

Report of Progress for 1878–79.

From the U. S. COAST and GEODETIC SURVEY.

HON. C. P. PATTERSON, Superintendent.

MR. J. E. HILGARD, Assistant in charge of Office.

Annual Report of Superintendent for 1877.

From GEN. H. G. WRIGHT, Chief of Engineers, U. S. Army.

Weitzel—Translation, 1880, of

Von Wex—Second Treatise on the Decrease of Water in Springs, Creeks and Rivers Contemporaneously with an Increase in Height of Floods in Cultivated Countries. 1879.

Chief of Engineers, U. S. Army—Report for 1879. Parts I, II and III, bound.

Weitzel—Translation, 1880, of

Von Wex—A Lecture on the Improvement of the Danube at Vienna. 1876.

One Pamphlet, 1880, containing—

Bixby—Notes on the Strength of Hollow Brick in Arches Whose Spans are Approximately $3\frac{1}{4}$ and $6\frac{1}{2}$ feet. 1880.

Bixby—Method of General Numerical Solution as to Both Solution of Equations and Interpolation in Series. 1868. Selected and Recommended.

Bixby—Translation of M. Croizette—Desnoyers (1876–77) Condensed Tables of the Rules to be Followed in the Application of the Different Processes of Foundations and Condensed Rules and Tables for Obtaining Curves of Pressure in Arches of Masonry Bridges.

Mississippi River Commission—Preliminary Report. 1880.

Casey—Annual Report to Joint Commission for the Completion of the Washington Monument. 1880.

Wex—A Lecture on the Progress of the Works of Completion of the New Improved Bed of the Danube at Vienna and the Lessons Taught Thereby; Together with a Description of the Catastrophe Produced by the Ice Gorge of 1880. Translated by G. Weitzel, Major of Engineers. 1881.

From MR. WM. A. INGHAM (member of the Club), Secretary of the Board of Commissioners.

Second Geological Survey of Pennsylvania—Reports; C^3, G^3, G^4, O^2 and V^2; bound.

Maps and Charts—C^3, I^3, R and T; bound.

Reports;—G^4, H^6, I^3, P text and R.

From the PENNSYLVANIA R. R. CO.

Length of Tracks of the Railroads Owned, Leased, Operated and Controlled, Dec. 31st, 1880.

From the ROAD MASTERS' MEETING of the ATLANTIC AND GREAT WESTERN R. R.
MR. CHARLES LATIMER, Chief Engineer.

Proceedings—Nov. 13th, 1879.

From the BOSTON WATER BOARD.
MR. LEONARD R. CUTTER, Chairman.

4th Annual Report, for the year ending April 30th, 1880.

From MR. JOHN KENNEDY, Chief Engineer of the Harbour of Montreal.

Harbour Commissioner of Montreal—Report in Relation to Improvements in the Harbour and Deepening the Ship Channel between Montreal and Quebec. 1876.
bound with

Harbour Master—Report for 1875.

Harbour Commissioners of Montreal—Annual Reports for 1877, 1878 and 1879.

From HON. THEOS. FRENCH, Auditor of Railroad Accounts.

Annual Report. 1880; bound.

From the late HENRY R. WORTHINGTON, of New York.

The Worthington Steam Pumping Engine, 1876; bound.

From the Author, CAPTAIN JOHN ERICSSON, New York.

Ericsson—His Contributions to the Centennial Exhibition. Elegantly bound.

From MR G. BOUSCAREN, Consulting and Principal Engr., Cin. Sou. Railway.

Lovett—Report of Progress of Work, Cost of Construction, etc., C. S. R. W. Nov. 1st, 1875.

Bouscaren—Report of Progress of Work and Cost of Construction, C. S. R. W. Dec. 1st, 1877.

Bouscaren—Report of Progress of Work and Cost of Completing and Maintaining the C. S. R. W. Jan 1st, 1880.

From MAJ. H. W. CLARKE, C. E., Syracuse, New York.

Report of the Regents of the University of the State of New York on the Re-Survey of the New York and Penna. Boundary Line. March 14th, 1879.

Journal of the Board of Supervisors of the County of Onondaga for 1880.

Manual of the Board of Supervisors of the County of Onondaga for 1880.

New York and Pennsylvania Boundary Line—Report of Commissioners to the Regents of the University of the State of New York. 1881.

Report of the Regents of the University of the State of New York on the Re-Survey of the New York and Pennsylvania Boundary Line. 1880.

From the Author, MR. ELIOT C. CLARKE, C. E.

Clarke—Paper on Sewerage. 1880.
—City Scavengering at Boston. 1879.

From MR. EDWARD R. ANDREWS, New York.

Photograph of Test Blocks exposed in Cape Fear River, below Wilmington, N. C., showing the preservation of wood by creosoting from destruction by the Teredo. Framed.

Proceedings of the Second Annual Meeting of the International Road Masters' Association, 1880.

From MR. GEORGE H. COOK, State Geologist of New Jersey.

Annual Report for 1880; with Progress Map of the State of New Jersey, 1880.

From MR. T. GUILFORD SMITH, Buffalo, N. Y., through American Society of Civil Engineers.

Phila. & Reading R. R.—Reports for the years 1854, '61, '62, '63 (2 copies), '65 and '66.

From PROF. H. T. BOVEY, Montreal.

Bovey—Cribwork in Canada.

From MR. WINTHROP SARGENT, JR., Altoona, Penna.

Nine large Photographs of Locomotive Engines—Penna. R. R. Standards.

From MR. GEO. S. COMSTOCK, Mechanicsburg, Pennsylvania.

Sellers—Improvements in Locomotive Engines and Railways, Cincinnati, 1849.

From MR. W. W. BRIGDEN, Erie, Penn'a.

Report of the Water Committee on the Accounts of the Water Commissioners for four years to 1878, etc.

Lane—Report on Mill Creek Sewer, 1880.

Annual Message and Report, Erie, 1881.

From MR. JOHN MCARTHUR, JR., Architect of the New Public Buildings, etc.

The New Public Buildings on Penn Square in the City of Philadelphia, 1880. Beautifully Illustrated.

The New Public Buildings—Section through Tower and North Central Pavilion—Large Photograph.

From the author, MR. W. BARNET LE VAN, of Philadelphia.

LeVan—The Weakening of Steam Boilers by

Cutting Holes in the Shell for Domes and Necks.

From the author, MR. HENRY CARVILL LEWIS, Geologist, Philadelphia.

The Surface Geology of Philadelphia and Vicinity.

On Siderophyllite—A New Mineral.

The Optical Character of Some Micas.

On Philadelphite (Sp. Nov.). 2 copies.

On a New Fucoidal Plant from the Trias.

The Trenton Gravel and its Relation to the Antiquity of Man.

From MESSRS. BURNHAM, PARRY, WILLIAMS & CO.

Illustrated Catalogue of the Baldwin Locomotive Works, 1881. Bound.

From MESSRS. JOHN WILEY & SONS, Publishers, New York.

Corthell—A History of the Jetties at the Mouth of the Mississippi River, 1880. Bound

From MR. P. H. BAERMANN, (Member of the Club).

Colvin—Topographical Survey of the Adirondack Region of New York. 3d to 7th Report 1874—79.

Coopertown, N. Y., Water Works. Photographs. Pumping Machinery, 1 view.—Method of Laying Submerged Pipe, 2 views.

From MR. WM. HENRY BALDWIN (Member of the Club).

The Sewerage and Drainage of Newport, R. I., 1880.

Waring—The Sewerage of Memphis.

From MR. CHAS. E. BILLIN (Member of the Club).

A General Description of the State of Indiana, 1879.

Prospectus of the Illiana Coal Company, 1881.

Caven—The Local Advantages of the City of Indianapolis as a Manufacturing Centre, 1876.

From MR. JOHN T. BOYD (Member of the Club).

The Fontaine Locomotive—Photograph.

From MR. CHAS. G. DARRACH (Member of the Club).

McFadden—Special Report upon Method to Provide Supply of Subsided Water for Philadelphia.

From PROF. L. M. HAUPT (Member of the Club).

The Seismological Society of Japan, Mr. W. S. Chaplin, Sec'y, Tokio.

Proceedings of General Meeting, April 26, 1880.

Report of Herman Haupt and Jas. L. Meigs, Consulting Engrs., on the Meigs Elevated R. R., 1881.

From MR. HENRY G. MORRIS (Member of the Club).

Photograph of Auchincloss' Averaging Machine.

From Mr. A. R. ROBERTS (Member of the Club).

The Goniometer used on the Survey for the Allegheny Portage Railroad—(*The instrument*).

From MR. A. W. SHEAFER (Member of the Club).

Messrs. Sheafer—Diagram of the Progress of the Anthracite Coal Trade of Penna. with Statistical Tables, etc., 1879.

From the Author, MR. DAVID TOWNSEND (Member of the Club).

Townsend—The Flow of Metals, 1878.

From COL. JAMES WORRALL (Member of the Club).

U. S. Engineers' Report Transmitting Report of Examination by Col. James Worrall, of Red Bank Creek, Penna.

LIST OF MEMBERS.

Additions to April 2d, 1881.

Honorary.

Walter, Thomas U., Architect, 720 N. Broad St., Phila. Elected Feb. 5th, 1881.

Active.

Lightfoot, Jesse, Civil Engineer, 61 Harvey St., Germantown, Phila. Elected Oct. 2d, 1880.

Stewart, James M., Civil Engineer, Mexican National Company, Calle Cadena No. 11, Mexico, Mexico. Elected Oct. 2d, 1880.

Corlies, Franklin H., Mechanical Engineer, Gang Foreman with Wm. Sellers & Co., 1507 Race St., Phila. Elected Oct. 2d, 1880.

Ludlow, Col. William, Civil and Military Engineer, U. S. Engineer, River and Harbor Improvements, 1125 Girard St., Phila. Elected Oct. 2d, 1880.

Borda, Eugene, Metallurgist and Mining Engineer, 326 Walnut St., Phila. Elected Oct. 2d, 1880.

Ferrell, Joseph L., Hydraulic Engineer, 2218 Race St., Phila. Elected Oct. 2d, 1880.

Smith, T. Carpenter, Mechanical Engineer, with Wm. Sellers & Co., 312 N. 33d St., Phila. Elected Oct. 2d, 1880.

Worrall, Col. James, Civil Engineer, Harrisburg, Pa. Elected Oct. 2d, 1880.

Reeves, David, Civil Engineer, President of Phœnix Iron Co., Phœnixville, Penna. Elected Oct. 2d, 1880.

Kneass, Srickland, Jr., Mechanical Engineer, with Wm. Sellers & Co., 418 S. 15th St., Phila. Elected Oct. 16th, 1880.

Hoopes, John J., Civil Engineer, Engineer Corps Penna. R. R., 2056 Pemberton St., Phila. Elected Oct. 16th, 1880.

Rutter, Charles A., Mechanical Engineer, 424 Walnut St., Phila. Elected Oct. 16th, 1880.

Hancock, Geo. W., Civil Engineer, 40th and Lancaster Avenue, Phila. Elected Dec. 4th, 1880.

Peelor, David, Civil Engineer and Surveyor, Johnstown, Cambria Co., Penna. Elected Dec. 4th, 1880.

JOHNSON, JOSEPH, Surveyor and Regulator 11th Survey District, Phila., 501 N. 40th St., Phila. Elected Dec. 4th, 1880.

GRAHAM, THOS. H., Gen'l Manager Candela M. & S. Co., care Messrs. Milme Bros. & Co., Laredo, Texas. Elected Dec. 4th, 1880.

WENTWORTH, CHAS. C., P. A. Engr., New River R. R. Co., Pearisburg, Giles Co., Va. Elected Dec. 4th, 1880.

MERRY, LEON T., Surveyor and Draugthsman, Lock Box, No. 1601, Phila. P. O. Elected Jan'y 8th, 1881.

COLLINS, T. EARL., Draughtsman, Baldwin Locomotive Works, 1431 Filbert St., Phila. Elected Jan'y 8th, 1881.

MERCER, JOSEPH, Surveyor and Regulator 6th Phila. Survey District, 1845 Frankford Ave., Phila. Elected Feb. 5th, 1881.

MUNROE, HENRY S., Adj. Prof. Practical Mining, School of Mines, Columbia College, N. Y. City. Elected Feb. 5th, 1881.

OSLER, WM. P., Assistant City Surveyor, Camden, N. J. Elected Feb. 5th, 1881.

THAYER, RUSSEL, Chief Engr. and Supt. Fairmount Park, Phila., 32d and Ridge Ave., East Park, Phila. Elected Feb. 5th, 1881.

SHEDAKER, D. HUDSON, Surveyor and Regulator 3d Phila. District, 425 S. Broad St., Phila. Elected Feb. 5th, 1881.

STOCKTEN, N. ALLEN, Mining Engineer, 144 S. 4th St., Phila. Elected Feb. 5th, 1881.

BALDWIN, WM. HENRY, Civil Engr., Special Duty, 10th U. S. Census, Yonkers, N. Y. Elected Feb. 5th, 1881.

McCLURE, JAS. R., Civil Engr., with Penna. R. R. Co., 233 S. 4th St., Phila. Elected Feb. 5th, 1881.

AUCHINCLOSS, W. S., Civil Engineer, 209 Church Street., Phila. Elected March 5th, 1881.

SMITH, W. BUGBEE, Mechanical Engineer, 209 S. 3d Street, Phila. Elected March 5th, 1881.

COFRODE, JOSEPH H., Bridge Builder, 3928 Locust Street, Phila. Elected March 5th, 1881.

WEST, PRESTON C. F., Asst. U. S. Engr. Mississippi River, 404 Market St., St. Louis, Mo. Elected March 5th, 1881.

SMITH, JOS. S., Civil Engineer, Pulaski Ave. above Apsley St., Germantown, Phila. Elected March 5th, 1881.

MURPHY, JOHN H., Civil Engineer with Penna. R. R., Rising Sun Lane, Phila. Elected March 5th, 1881.

BAERMANN, P. H., Constructing Engineer, Norwich Water Works, Nowich, N. Y. Elected March 5th, 1881.

EHLERS, PETER, Chief Engr. Franklin Sugar Refinery, 101 S. Front St., Phila. Elected March 5th, 1881.

CRAMP, EDWIN S., Marine Engineer, 1515 Oxford Street, Phila. Elected March 5th, 1881.

FAIRFAX, HENRY, Civil Engr. with Philadelphia Bridge Works, 259 S. 4th St., Phila. Elected March 5th, 1881.

LILLIE, S. MORRIS, Chemist Franklin Sugar Refinery, 307 Pine St., Phila. Elected March 5th, 1881.

TURNER, GEO. A., Mech. Engr. with Baldwin Locomotive Works, 1019 Wood St., Phila. Elected March 5th, 1881.

BLAND, GEO. P., Civil Engineer, 3214 Woodland Avenue, Phila. Elected March 5th, 1881.

RIDGWAY, WM. H., Mech. Engr. and Manufacturer, Coatesville, Chester Co., Pa. Elected March 5th, 1881.

SAYLOR, FRANCIS H., Civil Engineer, 259 S. 4th Street, Phila. Elected March 5th, 1881.

VAN HARLINGEN, M., Civil Engineer, Bristol, Pa. Elected April 2d, 1881.

MORRIS, GOUVERNEUR, Asst. Engr. N. P. R. R., Brainerd, Minn. Elected April 2d, 1881.

LUDLOW, EDWIN, Civil Engineer, 1125 Girard St., Phila. Elected April 2d, 1881.

MECHAN, JOHN, Civil Engineer, 1125 Girard St., Phila. Elected April 2d, 1881.

CONSTABLE, STEVENSON, Civil Engineer, American Nickle Works, Camden, N. J. Elected April 2d, 1881.

MARSTON, JOHN, Inspector of Rails, etc., Penna. R. R., 233 S. 4th St., Phila. Elected April 2d, 1881.

WHEELER, GEO. A., Civil Engineer, 1945 Christian Street, Phila. Elected April 2d, 1881.

RONEY, C. H., Civil and Mining Engineer, 15 S. 7th St., Phila. Elected April 2d, 1881.

Resignations.

REYNOLDS, GENL. W. F. Resigned Oct. 2d, 1880.

FREEMAN, HAROLD A. Resigned Jan. 8th, 1881.

Changes of Address.

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BRENDLINGER, P. F., Box 215, Bellefonte, Pa.

COLTON, O. B., Chief Engr. N. & W. Branch R. R., Bloomsburg, Columbia Co., Pa.

D'INVILLIERS, CAMILLE S., care Edw. V. d'Invilliers, 907 Walnut St., Phila.

FRANCIS, HARRY C., Manager U. S. Electric Lightning Co., Equitable Building, 120 Broadway, New York City.

HALSEY, JAS. T., cor. Front and Pearl Sts., Brooklyn, N. Y.

LEHMAN, A. E., 1905 Spruce St., Phila.

LYMAN, FRANK, Low Moor Iron Co., Low Moor, Allegheny Co., Virginia.

MCCOLLUM, THOS. C., Navy Yard, Pensacola, Fla.

PARRISH, EDWARD, Asst. Engr. Sevier Valley R'way, care Geo. A. Lowe, Salt Lake City, Utah.

SELLERS, HORACE W., Mech. Engr., with U. S. Electric Lighting Co., Room 3, 431 Walnut St., Phila.

THOMAS, GEO. C., 2019 DeLancey Place, Phila.

TRUMP, MICHAEL, Asst. Engr. Penna. R. R. Co., Union Depot, Pittsburgh, Pa.

WARREN, B. F., Titusville, Pa.

BOOK NOTICE.

CORTHELL—A HISTORY OF THE JETTIES AT THE MOUTH OF THE MISSISSIPPI RIVER, 1880. John Wiley & Sons, Publishers, New York.

The above work, written by the Chief Asst. and Resident Engr. during construction, is one of a class far from too numerous in engineering literature, being a complete and minute history of that most important and interesting work. It is too often the case

that amidst all the modifications of the original designs and all the complications that arise during the progress of engineering work, no record is kept, save in the memories of the engineers, and the profession is deprived of the benefit of an absolute record of the experience that has been gained. It is much regretted that so little, with regard to the execution of some of the earlier engineering works of our country, is known or can be known, now that many of the engineers connected with them have passed away, and it is to be hoped that the present generation will not fail to faithfully record its difficulties and achievements. In adverse criticism it might be said that, for a technical work, perhaps too much space is occupied by correspondence intended for personal vindication, but the real merit remains and we speak advisedly when we say that it has obtained high and intelligent appreciation.

Yours faithfully
Thos. C. Clarke

PRESIDENT DURING THE SECOND YEAR OF THE CLUB, A. D. 1879.

PROCEEDINGS

OF THE

[illegible]GINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

The Club, as a body, is not responsible for the facts and opinions advanced [illegible]

NOVEMBER, 1881. [No. 3.

THOMAS CURTIS CLARKE,

[illegible]resident of the Engineers' Club of Philadelphia, was born [illegible], Massachusetts, in 1827, and educated at the Boston [illegible] school and Harvard College, from which he graduated in [illegible] and began simultaneously the study and practice of his pro[illegible] under Capt. John Childe, Chief Engineer of the [illegible] Railroad, as was the custom in those days prior to the [illegible]ment of technical schools of engineering.

[illegible] about twenty years practice as an engineer and contractor [illegible] railroads, harbors, etc. Mr. Clarke took charge of the [illegible] of the bridge across the Mississippi river at Quincy, Ill., [illegible] the first of [illegible] dozen or more of iron bridges now [illegible]. This bridge was built by day's work. The [illegible] foundations being designed and executed by Mr [illegible] account thereof by him was published by Van No[strand] [illegible], 1869, pp. 76, [illegible] plates.

[illegible] completion of this bridge Mr. Clarke became [illegible] the firm of Clarke, Reeves & Co. of Phœnixville, [illegible] designed and constructed many miles of iron bridges [illegible], among which the Girard Avenue Bridge [illegible] [illegible]4.

Yours faithfully
Thos. C. Clarke

PRESIDENT DURING THE SECOND YEAR OF THE CLUB, A. D. 187[illegible]

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the facts and opinions advanced in its publications.

Vol. II.] NOVEMBER, 1881. [No. 3.

THOMAS CURTIS CLARKE,

Past President of the Engineers' Club of Philadelphia, was born in Newton, Massachusetts, in 1827, and educated at the Boston Latin School and Harvard College, from which he graduated in 1848 and began simultaneously the study and practice of his profession under Capt. John Childe, Chief Engineer of the Mobile and Ohio Railroad, as was the custom of those days prior to the establishment of technical schools of engineering.

After about twenty years practice as an engineer and contractor for railroads, harbors, etc., Mr. Clarke took charge of the construction of the bridge across the Mississippi river at Quincy Ill., which was the first of the dozen or more of iron bridges now spanning that river. This bridge was built by day's work, the masonry and foundations being designed and executed by Mr. Clarke; an account thereof by him was published by Van Nostrand, N. Y., 1869, pp. 70, 21 plates.

After the completion of this bridge Mr. Clarke became senior partner of the firm of Clarke, Reeves & Co. of Phœnixville, Pa., and has designed and constructed many miles of iron bridges, viaducts, etc., among which the Girard Avenue Bridge of this

city, and the Metropolitan Elevated Railroads of New York, are the most conspicuous examples.

Mr. Clarke is a member of the American Philosophical Society of Philadelphia, American Society of Civil Engineers, American Institute of Mining Engineers and the British Institution of Civil Engineers, London, besides the Engineers' Club of Philadelphia. He was President of the latter society during the year 1879.*

XI.

OUTLINE SKETCH OF MODERN MILITARY ENGINEERING.

By Col. William Ludlow, Member of the Club.

Read March 19th, 1881.

The science of Military Engineering has so far fallen into desuetude in the United States as to be in danger of becoming a lost art; not merely from the absence of any apparent necessity for its practical application, but because, from the lapse of time, its right to be considered as a legitimate branch of engineering knowledge may come to be disputed and the younger men of the profession may cease to regard it as a useful or profitable study.

In reading the foreign engineering journals one cannot fail to be impressed with the large share of space and thought devoted to the construction of war material, whether ships, forts or cannon, and with the eager general interest displayed in observing and commenting upon the practical development and value of every detail. With us, on the contrary, scarcely a word is said or written to indicate that any real importance or interest attaches to these subjects.

While measures for the protection and development of the metal-producing and cognate interests are hotly debated, and the revival of our moribund ship-building industries is discussed, developing great diversity of opinion as to the most suitable and

* Annual Address, April 19th, 1879. Volume I, p. 119.

effective methods of stimulating them into new life, the present condition of the Navy, actually inferior as it is to that of any civilized power and even to those of the South American Republics, is only made the occasion of a jest, and Congress itself can hardly be induced to grant a respectful hearing to the arguments in favor of making some provision for the national defense.

The improvement of the machinery of domestic and foreign trade, the construction of railways and increase of terminal facilities, the opening of water-courses and deepening of channels, are all prosecuted with unremitting vigor, careless of the fact that the increasing wealth of our coast cities and the improvement of the water approaches are yearly rendering them a richer and easier prey in the event of war. Engrossed with great enterprises and displaying a marvellous activity in all forms of peaceful industry, not only have we ceased to build vessels of war for the protection of our domestic and foreign commerce and the adequate representation abroad of the dignity and power of the Republic or to construct the fortifications necessary for the defense of our great seaports against the intrusion of an enemy, but we refuse to consider the possibilities even of future complications with other nations or to reflect upon what might be the immediately disastrous results of an outbreak of hostilities.

Without going into any general argument, it must suffice to point out that however remote such possibilities may appear, our present condition of national nakedness is in violation of all the teachings of history and contrary to the spirit of our political institutions; that the organic law of the country was careful to make such provision for the national defence as was then sufficient and practicable; and that large sums are annually expended by the United States and all the States individually in the organization, equipment and maintenance of the militia for that very purpose.

But under the conditions of modern warfare, no army, however numerous, brave, or well disciplined, would be of the least avail to protect our harbors against an attack by sea without the aid of suitable defensive appliances, and these appliances require years for their creation.

The object of this paper, inviting the attention of the Club to

these matters is first, to indicate briefly what are the modern methods of construction of war ships and coast defenses as employed by all nations with the exception of ourselves; and, secondly, to point out the connection existing between these branches of modern science and the general engineering and mechanical arts with the view of ascertaining if there be not some aspects of the case, of present importance and deep interest both to the engineering profession and the manufacturing industries of the United States.

Twenty years ago war ships were of wood and armed with smooth bore guns of small power, forts were of stone or brick, and with walls six feet in thickness were impregnable to assault and only to be reduced by a protracted siege. The operation of two main causes has brought about a complete revolution in methods of construction, involving both an abandonment of old materials and a total change of type. In March, '62, the "Merrimac," covered with railroad iron, had gone nigh to destroy the American Navy, in the harbor of Hampton Roads. Blown up, sunk, or stranded in their efforts to escape, the vessels of the fleet were at the mercy of the rebel ram; and not only was the perfect helplessness of wooden vessels, when exposed to the attack of an enemy clad in armor even of so rude a character, demonstrated, but it was also evident that the ports of the Atlantic seaboard were open to attack and that New York itself might be laid under contribution. The gravity of the situation was beyond precedent, when Ericsson's "Monitor" crept out from behind the walls of Fort Monroe, bearing her iron turret, engaged the "Merrimac" and drove her back to Norfolk crippled and shorn of dangerous attributes.

The necessity for armor protection was the lesson then taught the world; and the rapid and enormous subsequent development of the power of modern ordnance has compelled a constant increase in its capacity of resistance. In consequence, the Navies of the world, with the exception of our own, have been totally reconstructed within ten years, and the war ship of to-day is the epitome of the highest achievements of the mechanical arts. The hull of the modern armored vessel is of iron or steel, or both, and is driven by compound engines with one or more screw pro-

pellers. The portion below water is a double shell, divided into numerous water-tight compartments. The engines and boilers, the machinery and the magazines, are all placed below the water line; armored bulkheads protect them in front and rear, and a shot-proof deck arches over and covers all vital parts. The sides are clad with heavy armor, extending to some distance above and beneath the water line,—in some cases forming a belt from six to ten feet in width extending the entire length of the ship, in others concentrated in the middle third or half of the vessel,—for the protection of the guns and apparatus for working them. Electricity, steam and hydraulic power are used for most purposes to which they can be applied.

In the competition of nations, England, as might be supposed, has maintained her position as the leading naval power of the world, although France and Italy press close upon her. The English "Inflexible," however, is the most powerful and heavily clad war vessel afloat and may be regarded as the most recent type of the modern fighting-machine or mailed cruiser. Her displacement is in excess of 11,400 tons, of which nearly one-third is due to dead weight of armor. The central third of the length is built up into a citadel, rectangular in form, about 110 feet in length and 75 feet in width, rising some 10 feet out of the water and carrying two revolving turrets. The hull upon which these are borne is submerged some 6 or 7 feet beneath the surface and divided into 138 water-tight compartments. A shot-proof deck covers it, and at the bow is carried a heavy ram. In front and rear of the citadel are unarmored structures, also resting on the hull, furnishing quarters for the officers and crew and giving shape and seaworthiness to the vessel. The walls of the citadel are 41 inches thick, adjoining the submerged hull, and are composed of alternating layers of iron and teak. At the water line the iron armor is no less than two feet in thickness, in two courses of 12 inches each, separated by a course of teak.

The turrets are built of steel-faced iron, with a total thickness of two feet, 16 inches of which are metal, in two courses. They weigh each 750 tons, and by aid of hydraulic machinery can be completely revolved in 1¼ minutes, or as much more slowly as may be desirable.

The ship draws 25½ feet of water and can be driven at a speed of 14 knots, or nearly 16 miles, per hour.

The cost was over £650,000, nearly $3,150,000.

The armament consists of four 80 ton rifles, mounted in pairs in the two turrets, and capable of being fired in any direction. Like the ship itself, these guns are typical of the advance made in the construction of modern war material. Although not absolutely the heaviest guns afloat, since the Italians have rifled guns of 100 tons, throwing a shot of over 2000 lbs. weight,—and even heavier cannon have been projected by the French,—the English weapon has a tremendous capacity of destruction. The caliber is 16 inches. The shot weighs 1760 lbs., and with the full service charge of 460 lbs. of powder, leaves the muzzle with an initial velocity of over 1600 feet per second. The stored-up energy concentrated in this mass of metal is difficult to realize. At a distance of 1000 yards, the projectile is capable of piercing through 28 inches of solid iron. The full formula for penetration is somewhat complex and varies with the material, but an approximate value in inches is readily found by multiplying the diameter of the shot in inches by its striking velocity in feet per second and dividing by 1000. A statement of the penetration, however, suggests no adequate conception of the destructive energy of the bolt. To endeavor to realize this, the mind must rest upon the fact that the shock of its impact is only equalled by that which would follow from the instant arrest of the huge bulk of the vessel itself while moving at the rate of nearly 10 miles an hour. In other words, could the requisite directness of collision be secured and there were no yielding of material, the shot would stop the ship.

The French are making strenuous efforts to rival the English, while in some respects the Italians have surpassed both, since they are building two vessels of no less than 13,500 tons displacement with an armament of four 100 ton guns and 18 others of less weight. These vessels require four or five years to construct, will steam at the rate of 16 knots, and cost $4,000,000 each.

As between the offensive power of ordnance and the defensive capacity of ships, the contest is becoming unequal. The limit of weight and thickness of armor that are practicable for seagoing

vessels has probably been reached in the "Inflexible," while it is by no means certain that such is the case with reference to the power of cannon. The Italian 100 ton guns are capable of piercing 30 inches of iron at 1000 yards, while the French 124 ton gun,—reported as under construction,—is calculated to penetrate nearly 36 inches. The American 12 inch rifle, proposed by the Ordnance Board, by aid of improved powder and a high initial velocity will have the same power as the 100 ton Italian.

It follows that so far as the United States are concerned they may wisely leave the costly experimental building of armored ships to other nations and content themselves, for the present at least, with providing guns of sufficient power, and suitable vessels in which to carry them. Of these, many valuable types exist in foreign navies; the swift cruiser of iron or steel, like the English "Mercury," that has made 21½ miles per hour, or vessels of the "Cleopatra" type, with hulls of iron or steel sheathed with wood, combine great structural strength and durability with speed and seaworthiness and are capable of carrying a heavy armament. There are also the "composite" vessels, with frames of metal double planked and coppered. Such ships, though they may not cope in battle with the mailed war ships, can evade them, and are capable of most efficient work, from their superiority in speed and ease of handling. It is such vessels as these, of 3000 to 4000 tons displacement, speed of 15 to 17 knots, and carrying 10 or 12 inch rifles, that are needed to begin the rebuilding of the American Navy. They cost from $500,000 to $1,000,000.

The modification and strengthening of the defensive appliances of Forts and Batteries for the protection of harbors have gone hand in hand with those of ships, and the experiments upon the power of artillery and the defensive qualities of iron armor have answered for both. Stone and brick are necessarily abandoned and metal alone is relied upon for the permanent defense of exposed points. Forts and Batteries are now built largely of iron and steel, the immense improvements in the manufacture and consequent cheapening of the latter metal rendering it available in heavy masses.

The English, after long and costly experimenting, have pro-

visionally adopted for their coast defenses a shield composed of triple plates of steel-faced iron, each 6½ inches thick, separated by layers of teak of similar thickness. More recently it has been found desirable to add a fourth plate, giving a total thickness of 26 inches of iron and 15 or 18 inches of teak. These shields are in many cases adapted to existing works by inserting them into the front and masking the remainder of the battery with earth; only the iron surfaces being exposed to fire. When the aid of earth and masonry cannot be used, the turret system is adopted and the fort is a huge cylinder of iron plates pierced with embrasures, in one or two tiers, roofed over to guard against curved fire and with the magazines and hydraulic machinery for handling the guns and ammunition buried deep beneath.

In the course of experiments with various metals and their effect upon each other, the Germans have developed a successful use of chilled cast iron in heavy masses of curved section, as possessing some important advantages over the softer wrought or rolled metal. A shot that would penetrate a rolled plate would make no impression upon a chilled cast iron block, and unless of sufficient weight to crush the block, would itself be smashed to pieces. The Germans, therefore, and following their example, most of the other European countries, are building cast iron batteries of ovoidal section both vertically and horizontally and flattened along the ground. The front is a rounded casting, two to three feet thick, with the embrasure along its axis, and weighing 30 to 40 tons. The side castings adjoin this, and overhead are other pieces, completing the casemate; the whole fitting together and mutually supporting each other, so that even should cracks be made in the large castings, their arched form will hold them together and prevent destruction.

From this rapid review of the present condition of Military Engineering abroad, the general bearing upon matters of close and immediate interest to important American industries becomes at once apparent. It is the metals, iron, steel and copper, that are demanded in the construction of modern war materials; and their combination into such forms as shall endow them with the greatest efficiency and durability would call for the display of the highest science and skill of our mechanical engineers, as well as the most advanced results in the chemistry of metals.

Nothing, probably, could at the present time have so powerfully stimulating an effect upon the metal-producing and ship-building industries of this country, as the judicious annual expenditure, by the general government, of a certain fixed amount for the construction of adequate defenses for our commerce and harbors. We are now in a position to take advantage of the experience and costly investigations of other nations, and have a clear comprehension both of the results that are desirable of attainment and of the means of arriving at them. Without, for the present at least, troubling ourselves with the construction of heavy mailed war ships, we ought to build, yearly, eight or ten naval vessels with hulls of steel or iron, or of the "composite" type, and begin without loss of time the erection of the works necessary for the defense of at any rate the most important seaports.

It is to be remembered that the construction of the plant necessary for the manufacture and manipulation of the great masses of metal required by the exigencies of modern warfare, is itself the labor of years, and that this plant does not exist in this country; furthermore, that the commercial ocean vessels now building approach and even equal, in the requirements of tonnage, speed and great structural strength, the very types of ships that are the most desirable for naval purposes, and that therefore the same plant required for the one would, having been created, answer for the other.

The state of Pennsylvania, with its stores of coal and iron, its busy population largely engaged in mining and manufacturing and the metal industries, its advanced position in iron vessel building, and with the Delaware navigation offering itself as a safe and expeditious highway to the sea, enjoys advantages superior to all others, and should take the lead in presenting and advocating the national policy of protection which it has been the object of this paper to indicate.

XII.

THE ATTEMPT TO EXTINGUISH THE KEHLEY RUN COLLIERY FIRE.

By Dr. H. M. Chance, Member of the Club.

Read April 2nd, 1881.

The method of manufacturing and injecting the gas into the mine is novel in many respects, and it is that I purpose describing, as I have already published a paper in which the circumstances that caused its failure are briefly described.

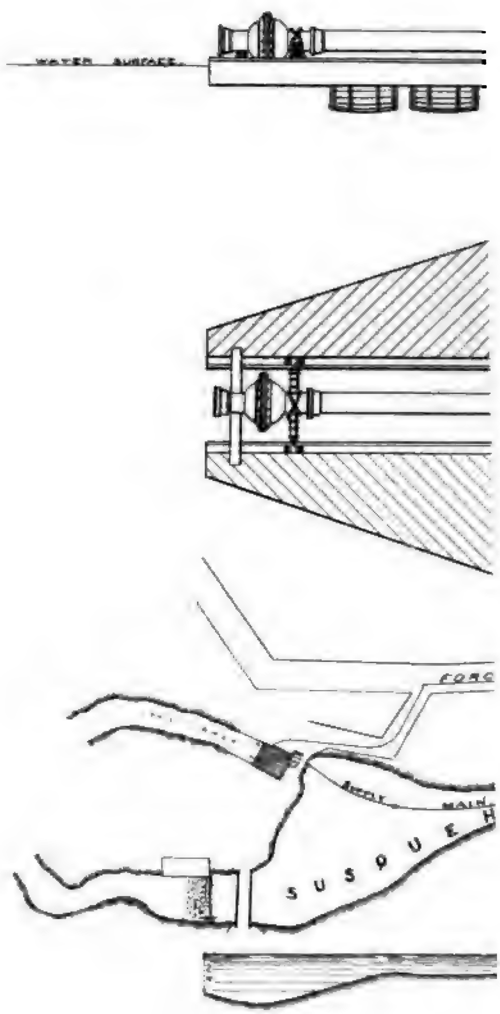
The gases were generated by a furnace built of brick, about five by ten feet, in two compartments of equal size. This furnace was open at the top but closed in below; the grate-bars were set about eighteen inches above its base, and the draught was *reversed*—from above downwards. The grate-bars had to be replaced frequently, and it was on this account that the furnace was built double.

A large delivery pipe, about 9 inches in diameter, was carried into the furnace beneath the grate-bars, and for a distance of about twenty feet this was water-jacketed, by building around it an open trough of two-inch plank.

The gas was forced into the mine through four three-inch delivery pipes by steam (siphon) injectors supplied with steam at 60 lbs. pressure. A flow of 1500 cu. feet per minute was supposed to have been obtained from each of these injectors, or a total of 6000 cu. feet per minute for all four.

The three-inch delivery pipes were driven down through the loose debris of a crop-fall directly into one of the breasts. For this purpose an inclined staging was built provided with adjustable guides, and the pipes were driven with a wooden ram raised by hand and allowed to fall upon a cap-piece screwed into the joint of pipe. The lower end of the pipe was protected by a cone-shaped cast-iron shoe, so arranged that it would drop out of the pipe as soon as the pipe pierced the debris.

One of the delivery pipes was carried into the mine through a diamond drill-hole.


WATER SURFACE.
SUPPLY MAIN

The temperature of the gases being very high, notwithstanding the main pipe was water-jacketed, spray jets were introduced a short distance beyond the injectors; and these caused a very notable decrease in the temperature.

The causes of failure are probably:

1. It was impossible to render the mine air-tight—the leakage was very great.
2. The temperature of the injected gases was too high.
3. The furnace may have been producing large quantities of carbonic oxide.

XIII.

SUBMERGED SUPPLY MAIN IN OTSEGO LAKE, N. Y.

By Palmer H. Baermann, Member of the Club.

Read April 2d, 1881.

The question of a water supply for fire protection, manufacturing purposes and domestic use has become of such importance in the majority of towns and villages that I venture to lay before you a detail of pipe laying employed in the construction of the Cooperstown Water Works.

The village of Cooperstown, N. Y., has a resident population of 1500, increased during the summer season to double that number; it is finely situated at an elevation of about 1200 ft. above tide at the foot of Otsego Lake, a sheet of water 10 miles in length, from 1 to 2 in breadth and with an average depth of 60 ft. Its waters are slightly hard, very clear and cold, the larger portion being received from springs in the bottom and along its shores.

The Cooperstown Aqueduct Association, organized under Special Act of the Legislature of the State of New York in 1835, collected the water from a spring about 50 feet above the village and conveyed it in pump logs to the town, where it was distributed to a limited number of consumers. As the consumption increased,

additional springs were obtained and, upon the failure of their combined flow, a small pump run by water power was located at the site of the present pump-house, "large two and three inch" iron mains laid, a few fire hydrants set and the question of a water supply for the future was supposed settled. Under this system, water was pumped into a wooden cistern, 14 ft. in diameter and 16 ft. deep, elevated 60 ft. above the pump and thence distributed through the "mains."

These mains, cast horizontal, uncoated, rapidly rusted through or filled up and, when they escaped these results, gave out from want of covering, being placed only 4 ft. below the surface in a climate where the thermometer falls to—28°.

In 1876, through the enterprise of Mr. Edward Clark, some additional fire protection was obtained by the construction of a small private gravity works having a head of 160 ft. The domestic supply was more than doubled when the gravity works were applied, but owing to the difference in pressure and want of any check-valve, the two systems could not be operated together.

While the domestic service might have answerd for a few years, a 4 inch main was found inadequate for the additional hydrants required by the growth of the village, and in the winter of 1879, it was decided to entirely reconstruct the works and the plan of of pumping by water power adopted. About 3000 ft. from the outlet of the lake is located the first dam upon the Susquehanna River with a fall varying from 7 ft. and 8 in. to 5 ft. and 4 in. Here was constructed the pump-house; a substantial brick building 25 by 30 feet, sufficient in size for two 50 inch Leffel turbines transmitting the power to two H. R. Worthington crank pumps of a combined capacity of 1000 gallons at 40 revolutions per minute.

The supply is taken independently to each pump through the suction pipes, drawing from the pump well, a tight masonry chamber, having two feed pipes 10 inches in diameter, each controlled by a valve, the lower one taking the water 1500 feet from shore and at a depth of 38 feet below the surface of the lake; the upper one connects directly with the forebay, and, in case of fire, furnishes the additional volume required from the river.

The discharge from the pumps is through a common air cham-

ber into an 8 inch main, one and one half miles in length, from which the 6 and 4 inch branches are taken, no line of 4 inch being over 500 feet in length unless supplied at both ends.

The distribution contains 3.5 miles of pipe, 45 valves, one drinking fountain and 22 fire hydrants.

The supply main into the lake is 4500 ft. in length. The pump-house, wheels, pumps and all work complete, cost between 34,000 and 35,000 dollars.

The detail of construction to which I would call special attention is that employed in laying the 4500 ft. of 10 in. supply main up the Susquehanna River and out into the lake.

In this work the ordinary method of laying, using the flexible joint of Mr. J. F. Ward, was first considered but, on account of cost, was abandoned; a combination of plain pipe laid in shoal water with a coffer-dam, and, in 10 ft. and over, using the flexible joint, was also abandoned for the same reason. It became evident that, if this work was to be done cheaply, the number of expensive joints must be reduced and the plain pipe increased, which could be accomplished if a number of plain pipes jointed were considered as one length and the flexible joint used to connect these sections.

These sections, composed of six, eight or ten pipes, must be lowered horizontally and supported at a sufficient number of points, so that the weight between supports would not strain the joint, and secured at the end to a moveable point so that, as the section was lowered, the ball joint describing an arc of a circle, the float might pass ahead.

At the start it was intended to use two flexible joints per each length of float, but in shoal water up to 10 ft. it was found unnecessary and the pipes were lowered gradually on an inclination, the yielding of the joints causing the section to assume the curve shown in Fig. 7.

The float from which the pipes were lowered was composed of four timbers placed parallel, the distance between the central ones being four feet, and between the outside ones sufficient to receive a kerosene barrel. As each barrel when submerged had a bouyant effort of about 400 lbs. the total supporting power of the float was 30,400 lbs. disregarding the effect of the timbers. The

maximum load consisted of 15 to 17 lengths of pipe, weighing 620 lbs. each, the flexible joints, men, etc., or approximately 12,000 lbs. with which the draft of the float was 27 inches.

The elevation and plan, Figs. 1, 2, show the construction of the float, the upper work being so arranged as to leave a clear opening of 4 ft. from end to end. The track upon which the truck ran was spiked to the inside timbers just above the water line and extended the whole length. While the carriage was intended to be used only in lowering the long sections, it became very convenient in changing the position of the float; the pipe, resting upon the bottom and on the truck on the float, gave a rigid connection with the bottom.

The float was made in four sections which, in straight stretches of the river and on the lake, were placed in line, but on the bends were deflected so that, with the 4 foot opening, pipe could be laid on any curve obtainable in the joint room, with the same facility as upon land. The four foot space was just sufficient to allow of a small boat carrying one length to enter, and thus each pipe as brought from the shore (in the river work) was delivered in position, the spigot entered, a timber placed under the bell end, and the boat backed out. The joints up to a depth of ten feet were, at the suggestion of Mr. Ward, made of dry pine wedges sawed on the circle of the outside diameter of the pipe, these wedges were placed close around the pipe, then three or four small wedges entered to tighten them on the circumference and the whole driven in the same way and with similar tools as in land works. The joints when lowered as in Fig. 7, were compressed upon the top and drew slightly upon the bottom, but when they were finally in position on the bottom, the wooden wedges had gone back; the greatest pull of the joint was only one-half inch in one particular case, generally from one-eighth to one-quarter of an inch.

Figs. 4 and 5, show the alignment and profile of the supply main from the pump-house to the strainer, the position of the ball-joints are shown at x. x. The advantage of the wooden joint was demonstrated by the fact that only five ball-joints were used in the first 3000 ft.

This portion of the work, although in shoal water, consumed

more time from the necessity of changing the direction of the sections of the float, but the rate per day averaged 150 ft. for three men; in the lake on straight work the rate was increased to 300 ft. per day and on one occasion 450 ft. were laid.

The intention was to lay the whole line before the lake froze over, but the non-arrival of the pipe prevented, and the following changes became necessary. The height of the upper work was increased seven feet to allow of a greater length of fall in the blocks. In warm weather the blocks were allowed to go under water, but when the temperature fell to near zero, it was desirable to keep every thing out of the water excepting the one rope supporting the pipe.

The method of procedure was as follows. After the pipes were placed on the float and the joints run and driven the ropes were attached as shown in Fig. 1, a.

The ropes holding the entire weight excepting a portion of the first two lengths of pipe fastened to the truck, were four in number, $\frac{7}{8}$ manilla, new, and supported a maximum weight of not far from 6000 lbs. These ropes were 60 ft. in length, one end having a three inch ring of $\frac{3}{8}$ iron. The rope was placed around the pipe and passed through the ring, attached to which was a small line for drawing up the rope. Fig. 1, a. a.

The blocks were of wrought iron, three sheaves each for $\frac{5}{8}$ rope. They were suspended as shown in Figs. 1 and 2, b. The rope around the pipe was fastened to the hook of these blocks when close up, so that the greatest distance could be lowered in one operation, generally about 10 feet; the line from the blocks passed around snatch blocks secured to the posts of the float and terminated in pairs in a ring on each side as shown in Figs. 1 and 2, c. c. d. d. This ring was attached to a three sheave self-sustaining block, which held the pipe at any position. By this arrangement the weight was distributed on thirty pulleys, and as the diameter was small the friction greatly aided in lowering, two men facing each other could with the rope, Figs. 1 and 2, e. e., *steadily* lower the entire length. The forward end was secured to the truck which moved on the track, and when the pipe grounded, a ball-joint was connected with pipe projecting above the water, which brought the line horizontal, and another length

placed on the float. As the upper work was not high enough to run the whole depth at one time without getting the blocks under water, when the pipe had been lowered so as to bring the blocks within a foot of the surface, the first and third pair of blocks were hauled very taut, relieving the second which was then run close up and the supporting rope attached again; then the second and fourth tightened and the first and third run up; the fourth having been lengthened at the same time as the second. When all were lengthened the pipe was again lowered. In some instances it was found best to dispense with the three sheave blocks, and by taking a turn around the posts and stationing a man at each rope the length was lowered without the additional pulleys.

When upon the bottom the supporting rope was loosened from the block and by drawing on the small line the ring came up, pulling the rope around the pipe.

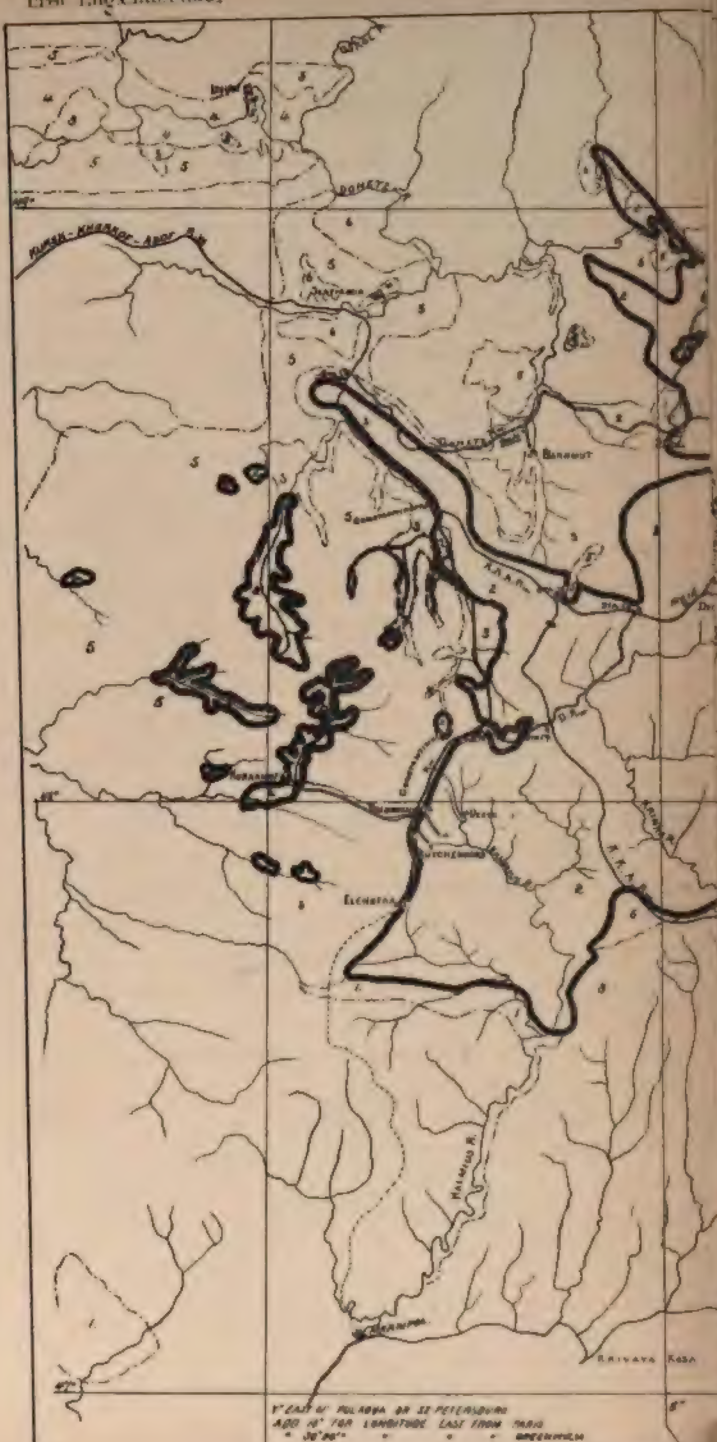
The end of the main is supplied with a strainer which is held from the bottom by a timber frame 12 ft. square, Fig. 5, a., and by the use of three ball-joints as shown, by hoisting on the chain attached to the buoy, the strainer can be brought to the surface and cleaned in case of necessity.

As already stated, the last 1000 ft. were laid during the winter and by keeping the ice removed in front of the float only as fast as it was necessary to move the float forward, little work was lost by channel freezing during the night.

The channel cut was 16 ft. wide in ice from 20 to 28 inches in thickness.

The cost of this work was approximately as follows:

Float, pulleys, cordage,	$350 00
Tools, incidentals,	126 00
Cutting ice,	70 00
Iron pipe,	4,275 00
Ball-joints,	725 00
Labor,	308 00
Total,	$5,854 00


DONETZ R.
BAKHMUT
KALMIUS R.
KRIVAYA KOSA

ETCH OF RACHETTE IRON FURNACE
AT
HE BARANCHINSKY IRON WORKS
IN THE NORTH OF THE
URAL MOUNTAINS.

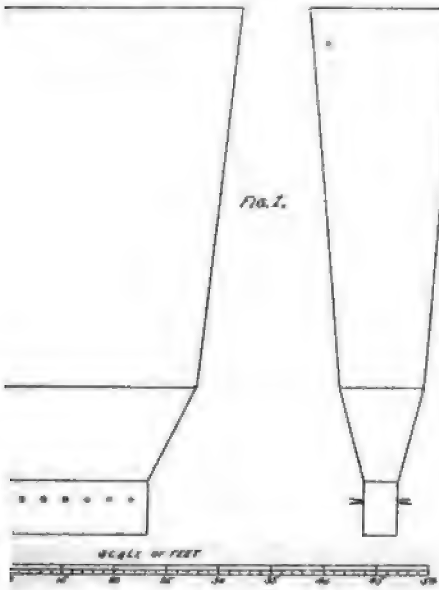


FIG. 1.

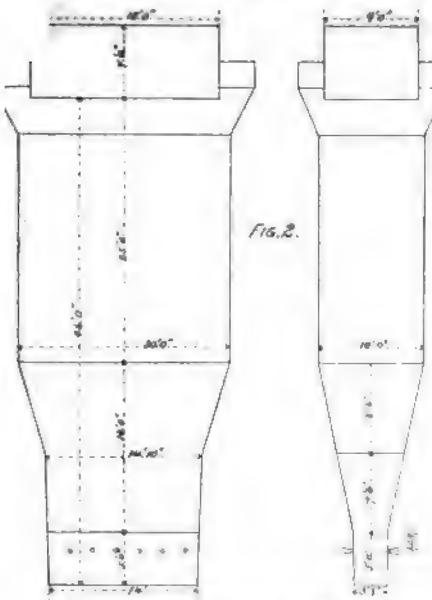


FIG. 2.

SKETCH OF FURNACE Nº 3.
AT
NISHNI TAGILSK
URAL MOUNTAINS

XIV.

NOTES FROM A JOURNEY IN SOUTHERN RUSSIA.

By Mr. Henry A. Vezin, Member of the Club.

Read March 19th, 1881.

The great difference which exists between this country and Russia may make it of interest to some of the members of this Club to obtain accounts from personal observation during a professional visit, extending particularly through the southern part of Russia, from the beginning of February to the end of July of last year. The difficulty that every foreigner has to encounter when in a strange land, the language of which he cannot speak, seemed aggravated in my case when we consider the genial Russian tongue, which does not show the slightest resemblance to any one of the three modern languages that I have at command. Owing to my deficiency in this respect, natives, who are my superiors as linguists, kindly took charge of me, and thanks to their unexcelled courtesy and to their thorough knowledge of the country, I obtained more true information in less time than if I had, at the risk of injuring my jaw, first learned this very difficult language.

The object of this visit was to obtain as much information as possible about the coal and the iron ores of the south, more especially of the Donetz basin, with the view of deciding the advisability of aiding, by American capital, the development of the natural resources said to exist there. I confine myself to coal, iron and transportation, and to such other matters as have a more or less direct bearing upon the subject.

Note.—1 ruble=100 copeks.
Value of 1 paper ruble is 51 cents.
1 sajen=3 arshins=48 vershoks=7 ft.
1 arshin=2 ft. 4 in.
1 vershok=1¾ in.
1 verst=500 sajen=3500 ft.=0.663 miles.
1 dessiatin=2500 square sajen=2,812 acres.
1 pud=40 Russian pounds=36 pounds avoirdupois.
1 ton (2240 pounds avoirdupois) = 62 puds.

Plates XIII and XIV show the position of the Donetz or Little Don coal formation, the eastern and central portion lying in the lands of the Don Cossacks, the western in the Ekaterinoslof government. It has a length of 160 miles from east to west, and an average width of 60 miles. The surveys and explorations, upon which General Von Helmersen's geological map of this part of Russia is based, were commenced in 1864 and the map was published in 1872. It represents the boundaries of the formations on the surface, so that only that part of the region on which the coal formation crops out is marked as such. The outlying islands, east and west, are undoubtedly parts or an extension of the main field, overlain on the west and north by chalk and by tertiary formation on the east. The method employed in making a geological survey of a single estate consists in digging a ditch across the line of stratification down to the rocks (generally 7–15 ft. deep) and sinking prospect shafts on the veins down to firm coal. These prospect shafts varied on one estate (Volyntsevo) from 35 ft. to 150 ft. in depth. A plane-table survey is made of the outcrops of the limestones and sandstones, which are very distinct, not having been nearly so much eroded as the accompanying soft shales, and the coal veins are drawn in conformably to these rocks.

So far as my observation goes, the seams are very regular, not far apart and small, varying from 2 ft. to 4 ft. in thickness. As they have not been worked out, shafts of moderate depth will be sufficient for some time to come. The quantity of water encountered at the depths of the present shafts (200 ft. to 300 ft.) is small, and, as labor is cheap, the extraction of the coal is not very expensive.

On the estate Volyntsevo, through the centre of which runs a saddle, or anticlinal, the upper part of which has been eroded, a careful survey, as described above, having been made on the southern portion, the coal veins north of this anticlinal were all found by prospecting shafts at exactly the same distance from the beds of sandstone or limestone at which they lay from the corresponding rocks on the south. Veins have been found not to vary in thickness for a distance of 27 miles on their course. They preserve their relative position to the sandstones and lime-

stones, as well when these diverge, as when they lie parallel. The claim made by the Russians that their coal veins are not faulted, seems to be confirmed by what I was able to see. Even where the veins were very much bent, forming steep saddles and basins, or much folded, there were no signs of a break. Further developments may, however, prove the existence of faults. As the outcrop of the veins is not overlain by another formation, and the workings are neither deep nor very extensive, little or no firedamp has as yet been encountered.

The coal measures consist of shales, sandstones and limestones of the lower carboniferous formation. The coal usually has both roof and floor of shale, sometimes rather silicious, and occasionally changing into sandstone. Both the sandstone and shale carry a good deal of mica. In two instances I found limestone as the roof of a vein.

The coals vary in quality from the hardest anthracite to the softest gas coal. The eastern and southern portion of the district contain anthracite, the northern and western bituminous and gas coal. At Kurakhofka, on one of the outlying western islands, the coal is nearly like brown coal or lignite. The best developed basin in the southeast portion, or anthracite region, is that of Grushefka, the western half of which is developed by 400 pits. The eastern half is not known, as the alluvial deposit overlying it is very thick. One proprietor is said to have sunk a shaft through 280 ft. of this deposit. There are 4 veins of coal, the 1st or upper one, 4 ft. 8 in. thick, the 2d, 3 ft. 6 in., the 3d, 3 ft. 6 in., and the 4th, 35 in. The 1st and 2d are not worked, as the coal is more friable than that of the others. A cross-section from south to north shows the veins as pitching at the southern outcrop 8° to the north; this changes gradually to 5° at a depth in the 4th vein of 280 ft., and to nearly horizontal at 420 ft. The bottom of the basin would be found at a depth of 840 ft., from which point the veins gradually rise, the pitch to the south increasing until it becomes 30° at the northern outcrop. The coal from the 3d and 4th veins, which I saw used in the foundry at Lugansk (see map), seemed to me harder than that of Pennsylvania. It shows the stratification and has no concoidal fracture. It is said to contain 91 to 95 per cent. of fixed carbon.

$2\frac{1}{2}$ per cent. of hydrogen and $1\frac{1}{4}$ per cent. of oxygen and nitrogen, and to have a specific gravity of 1.5 to 1.7. The same kind of coal is found on the headquarters of the Nesvitay River, 20 miles west of Grushefka, and in the basin of the Kundruchia. The latter contains 200,000 acres, and extends 15 miles west and 35 miles east of Sulin, a station on the Kursk-Kharkof-Azof Railway, 12 miles N. N. W. of Grushefka. A cross-section of the Kundruchia basin at Sulin shows the dip of the coal veins and accompanying strata to be 38° to the north at the southern limit. This gradually changes from 30° to 8°, and then, passing the sinclinal, the dip to the south commences with 8° and finally grows to 27° at the northern outcrop. The width of the basin at this point is 10 miles. A Russian engineer told me that in smelting at Sulin with this coal, in a furnace of 45 ft. height, he was obliged to use a pressure of blast of 10 lbs. per sqr. in. The coal is much liked for domestic purposes and is also used on locomotives, but an objection is urged against (?) it, namely, that it "makes steam too fast," so that the engineers prefer to use it mixed with bituminous coal. At Rostof I saw it delivered on the locomotives in lumps 1 ft. to 2 ft. in diameter, broken down to pieces of 5 or 6 in. in diameter and used without admixture of bituminous coal. The bed in the fire-box was kept so thick as easily to account for the objection mentioned.

In mining the coal it is undercut for a length of 70 to 100 ft., slit at each end of this distance and broken down with wedges. The entire mass usually comes down in a single piece and has then to be broken up with hammers into pieces of about $1\frac{1}{2}$ ft. in diameter, by which operation about 10 per cent. of stuff of less than 4 in. in diameter is produced. This latter is considered dust or waste, so that the Russian buckwheat size is 4 in. in diameter.

The anthracite farther to the north and west, as at Doljik 57 miles N. W. of Grushefka, on a river of the same name flowing into the Kamenka, and on the river Khrustalnaya 70 miles W. N. W. from Grushefka, is not so hard as at the latter place and contains but 87–89 per cent. of fixed carbon. At Amvroziefka on the Krinka River, 80 miles nearly west from Grushefka, a very free burning anthracite is mined. It is used by Mr. Illovaisky in his foundry at Zuefka, $16\frac{2}{3}$ miles N. W. from Amvro-

ziefka. This was not in blast at the time of my visit, but he and his French engineer both assured me that they used it with satisfactory results. In the ordinary tile stoves of the country it burns freely and attains a high temperature in a short time after closing the stove doors.

Proceeding from these points towards the north, or west, the coal becomes softer and more bituminous, until at Lissitchansk, in the northwest corner, it is a gas coal, which gives lump coke only from lump coal, yields but 30 per cent. and that of a friable nature.

It is said that the sandstones and shales of the anthracite region, as also the iron ores, are much harder than those of the region of softer coals.

I add the results of trials made under the boiler of the School of Mines of St. Petersburg, with coal from Rutchenkovo, from Cardiff and from Newcastle, and with wood, for the purpose of determining the heating power of each. The mine of Rutchenkovo belongs to the French company near Hughes's Works on the eastern part of the coal fields. (*Société générale minière et industrielle.*)

All three kinds of coal were broken with a hammer and screened. Rutchenkovo gave 70 per cent., the Newcastle 20 per cent. and the Cardiff 15 per cent. of fine stuff that passed through a screen with openings of 30 mm.

Each experiment lasted from 3½ to 7 hours.

Size of Coal.	Weight of water in kilogr. evaporated by 1 kilo. of fuel.			
	Rutchenkovo coal.	Newcastle coal.	Cardiff coal.	Wood.
Fine, less than 30 mm. diam.	7.548	6.749	8.631	
From 30 mm.–50 mm. diam.	8.107	6.037	8.465	
Pieces over 50 mm. diam.	7.660	6.878		
				2.778

The wood was half pine, half birch, pieces 21 in. long and 1 in. to 2 in. thick. Weight of a cord of such wood, 3277.6 lbs. Taking the mean evaporating power of 1 kilo. of Rutchenkovo coal at 7.7 kilogr. of water, 1 ton of this coal is equal to 1.9 cords of the kind of wood used above.

The detailed reports of these trials are contained in the Russian *Mining Journal* for January, 1880.

Two tests of Yastchikovo coal made on locomotives of the Rostof-Vladiskafkas Rw. gave 8.4 lbs. and 8.36 lbs. of water evaporated for 1 lb. of coal and in every other respect it proved satisfactory. Yastchikovo lies near the Donetz Rw. 16 miles E. N. E. from Debaltsevo.

The coke made from the bituminous coals is firm and of very good quality. One sample from a large pile that was made out of fine stuff in meilers in a rather crude way contained 8 per cent. of ash. But particles of slate $\frac{1}{4}$ in. to $\frac{3}{8}$ in. diameter could be seen distributed through it, owing to the coal not having been washed. Were the coal prepared on the machines used in Westphalia, where the constructors of dressing works guarantee a coke containing not over 4 per cent. of ash, equally pure coke could be expected.

Samples of coal taken by me across the entire vein from different veins at depths of from 7 ft. to 210 ft., measured vertically, gave tenure in per cent. as follows:

	1	2	3	4	5	6	7	8	9	10
Coke	91.7	91.5	82.7	82.3	81.6	81.4	72.9	66.8	62.3	57.6
Volatile matter	8.3	8.5	17.3	17.7	18.4	18.6	27.1	33.2	37.7	42.4
Ashes	17.8	7	13.1	9.5	7.76	4.9	4.9	4	5.5	3.8
Depth in ft. at which sample was taken	30	200	210	40	60	7	60		*70	35

Mixtures in different proportions of samples 1 and 9 were coked in a crucible. Even with 70 per cent. of the anthracite 1 and 30 per cent. of No. 9 a passably firm coke was produced.

On the estates that I visited the horizontal distance between the workable veins varies from 150 ft. to 700 ft. and 4 to 8 veins could be worked from one shaft. In calculating the amount of coal under ground I have counted on an extraction of only 66 per cent., though I think that it would amount to 85 per cent. in practice. A width of the outcrop of 140 ft. to 210 ft. was rejected as unfit for market. Veins of less than 2 ft. thickness were neg-

* Or 350 ft. measured on the slope, which pitches 30° to the north.

lected, though thinner ones, especially if they have a steep pitch could be profitably worked. (In Mariemont near Charleroi, in Belgium, I was told that one of the very profitable veins is only 16 in. thick.) The average quantity of coal per acre to a depth of 700 ft. is 7100 tons, where the dip is 12° to 15° and 3300 to 4400 tons, where the veins are steep.

As an example of the mines in the south of Russia, I will take the development on the two veins, which are worked at Yastchikovo, lying south of the Lugansk branch of the Donetz R. R., near Uriefka station.

The dip of the veins is 12° to 15° to the north. The upper seam, 2½ ft. thick, is worked by a shaft, 210 ft. deep, 9 ft. x 9 ft., with three compartments, two for the cages and one for the steam and water pipes of the underground pump.

A slope 945 ft. long is connected with the bottom of the shaft, and was sunk, partly for development, partly for ventilation. The shaft house contains a rotary engine of 30 horse power, for hoisting and two boilers to supply the engine and the steam pump at the bottom of the shaft. This pump works in winter about one fifth of the time. The coal is trammed under ground in cars of 800 lbs. capacity, hoisted, each cage holding one car, and taken to the screens.

The second or lower vein is 4 ft. thick, has a shaft 182 ft. deep connected with a slope 560 ft. long, a rotary engine for hoisting, of 22 horse power, two boilers, a steam pump at the bottom of shaft and a separate boiler and hoisting engine at the head of slope. This vein will be cut by sinking the shaft of the upper vein to a total depth of 350 ft.

The shaft houses, repair, carpenter and blacksmith shops, office, and house for employees, small houses for married workmen, and larger ones for those who are unmarried, are built of stone.

A railway of 30 inch gauge, 4 versts in length, connects the mine with the Donetz R. R.

To show the cost of constructions at present, I quote the following prices, as given to me:

Earthwork, including hauling a short distance, 60 cop. per cub. yd.

Stone masonry, in walls, . . .	11.73 rubles per cub. yd.
Brickwork, walls, ...	23.92 " " " "

or 17.23 rubles per thousand. Size of bricks, 10½"x5"x2¼". Roofs for a span of 38 ft., 26.30 roubles per square (100 sq. ft.).

At Yastchikovo the sinking of shafts, construction of buildings, putting up machinery, everything complete and ready for the extraction of coal, was done in 7 months at an expense of 120,000 rubles.

With this machinery there was no difficulty in raising over 3000 tons per month from one of the shafts. Better hoisting works can be found on many of the mines.

The usual method employed is pillar and stall work. The roof stands with comparatively little support. There is not much dead matter that can be used in gobbing up, as the intercalations are generally not over 1–1½ inches thick. But after the extraction of the coal the floor rises slightly, portions of the roof scale off, and in a month's time the open spaces are filled up without any disturbance to the veins above. The timber that I saw used, and that is sometimes in part recovered, was taken from the ravines of the surrounding country, where alone trees are to be found.

The selling price for coal on cars is usually 7 copeks per pud, or 4.34 rubles per ton, and the proprietors count the cost at half the amount, or 2.17 rubles per ton. The estimated cost, 2½ rubles per ton on cars, given in Appendix A, is based on actual experience at Yastchikovo. If the mines are to be worked on a large scale for at least ten years, the cost per ton for a production of 500 tons per day from one colliery, or 500,000 tons per annum from 4 collieries, would be:

All expenses due to mining, including labor, material, officers, mine transportation, etc., per ton of 2,240 lbs., @ 2.50 rubles., (1 ruble=$.51)	$1.28
10 per cent. redeeming fund, and 6 per cent. interest upon investment of $750,000 for collieries, fixtures, buildings, dwellings, etc., ... , . . .	.24
Royalty per ton, ...	.15
Total per ton, ...	$1.67

equal to 3.27 rubles per ton.

Appendix B gives the cost of haulage by chains and by wire ropes.

The coal is now generally hauled from the mines to the railroad on sleds in winter at 35 copeks, and on wagons in summer at 23 copeks per ton and mile for short distances, say 2 versts. At one mine the contract price in summer is as low as 10¼ copeks per ton and mile for a distance of 11 miles, the owner of the mine furnishing the teamsters with pasturage for their oxen.

Each sled, drawn by a small horse or pony, carries 300–500 lbs. of coal. One driver sometimes takes charge of 2 or 3 sleds, attaching the bridle of the pony in the rear to the sled in advance. In summer a yoke of oxen will haul one ton in a wagon. Wherever I saw accumulations of coal at the railway stations, it always lay on ground that was lower than the track. When it is to be shipped it is carried up an incline, in baskets or hand barrows, and loaded into the cars.

Appendix C gives the production of coal in the Donetz basin and the estimated consumption for 1880. It is claimed that factories, mills and machine shops, public works and private individuals make requisitions for only the amounts that they feel sure of getting, and that their demands would be vastly higher, if they could depend on a supply.

The cost of transportation is as follows:

	Rates of freight	
	Per Verst and Pud.	Per Ton and Mile
Donetz Railroad,	$\frac{1}{55}$ copek.	1.69 copeks.
Kursk-Karkoff-Azof R. R.,	$\frac{1}{60}$ "	1.55 "
Kursk-Moscow Railroad,	$\frac{1}{65}$ "	1.433 "
Constantine Railroad,	$\frac{1}{42}$ "	2.214 "

Freight from Moscow to St. Petersburg (distance 604 versts or 403 miles) is 10 copeks per pud, or 6.20 rubles per ton, equal to 1.54 copeks per ton and mile.

From St. Petersburg to Moscow it is 8 copeks per pud, or 4.96 rubles per ton, equal to 1.23 copeks per ton and mile.

The following table gives the cost of coal in different cities, taking Uriefka as the starting point. The cost on cars is taken at 3.27 rubles, as calculated above, and no allowance made for shrinkage or for possible small extra charges (of railroads), that I do not know of.

Starting Point.	Destination.	Distance.		Freight.	Cost of 1 Ton of Coal.	
		Versts.	Miles.	Per Ton.	On Cars.	At Destination.
Uriefka.	Nikitofka.	58	38⅔	R. 0.654	3.27	Ruble, 3 92
"	Kharkof.	365	243	3.826	3.27	" 7.10
"	Kursk.	594	396	6.192	3.27	" 9.46
"	Orel.	738	492	7.565	3.27	" 10.83
"	Tula.	915½	610	9.259	3.27	" 12.58
"	Moscow.	1096½	731	10.985	3.27	" 14.25

The price of firewood in the different towns varies very much. In Moscow it costs in quantities 35 rubles per cubic sajen, or 13.06 rubles per cord, which is equivalent to 26.12 rubles per ton of coal, as the heating power of one ton of coal is equal to that of two cords of wood.

In Karkof, a city of 100,000 inhabitants, wood costs 23 rubles per cubic sajen, or 8.58 rubles per cord, equivalent to 17.16 rubles per ton of coal.

How soon, after being assured of a regular supply of coal, the inhabitants of the different cities would use it instead of wood; how soon, for instance, Moscow would use over a million tons per annum, the amount which it is claimed it now needs (see appendix C), I am unable to say.

Among the causes, which, I think, prevent the rapid adoption of coal for fuel in the interior, the principal ones are probably the small scale upon which the coal is mined, and the not very economical method of handling it, but more especially the lack of sufficient transportation, of which the mine owners complain, and, as I believe, with good reason. Supplies of coal cannot be guaranteed to consumers, and they are, therefore, unwilling to change from the use of wood fuel. In any event, I think that its adoption, at least for a few years, will be of slow growth.

The city of Tula, containing over 60,000 inhabitants, is called the Russian Birmingham and Sheffield combined and would, no doubt, take its entire supply of fuel from the Southern coal fields. English coal sold in 1880 in St. Petersburg at R. 9.30 per ton; freight to Moscow is R. 6.20, so that a ton would sell for R. 15.50 in the latter city or R. 1.25 more than the cost price of Donetz coal. If, by running trains belonging to the mines, freights could be reduced, the Donetz coals would probably find

a market in Moscow, especially as they can be delivered during the entire year, while the closing of the harbor of St. Petersburg by ice prevents English coals being brought in during six months of the year.

The coal from the fields of Central Russia, near Moscow, I am told, is of poor quality, very impure, has a large percentage of volatile matter, and does not coke.

Though Kief, a city of over 100,000 inhabitants, lies on the Dnieper river, which drains a thickly wooded country, and in a district where lignites have been discovered and mined within the last fifteen years, requisitions for Donetz coal are made from there (see Appendix C), and no doubt in many towns south of Moscow and east of Kief a large demand could be created, but not in a very short time.

The opening of mines on a large scale, based on prospective coal trade alone, might lead to sad disappointment. The railway companies show no inclination to co-operate, their means of transportation are often insufficient, and they don't care to afford facilities, especially as the government guarantees a fixed rate of interest on their bonds, whether it is earned or not. As appendix C shows, the estimated production of 1880 is 1,387,823 tons, i. e. 95.6 per cent. more than the amount of requisitions for the same year. With the anxiety to produce which these figures indicate, the owners of small mines could, by hiring the peasants of the immediate neighborhood at low wages, by working near the surface and with little regard for the future, keep prices down so low, as to compel the large mines to sell with little or no profit for a few years. But a company carrying out an enterprise such as was projected, comprising the opening of mines, the construction of a railroad from the mines to the sea of Azof and connecting with the roads now existing, the construction of a harbor at the sea of Azof, the erection of iron furnaces and steel works of a capacity of 70,000 tons of steel rails per annum, with a guaranteed sale of a large part of this product for a number of years, would be much more favorably situated than a mere coal company. It would be its own consumer of coal and could take advantage of any coal trade, foreign or domestic, that might be offered, as an additional source of profit.

I see no reason why this coal should not come into competition with the English coals for domestic use, except that it is more friable, and might therefore at first be less favorably received. The present consumers very much prefer even coking coal in lumps, and to break it themselves. As shown in the comparative trial, described between the New Castle, Cardiff and South Russian coals (the latter from Rutchenkovo), the English coals, when broken by hammer, gave 15 to 20 per cent. of stuff less than 1¼ inches in diameter, while the Russian coal gave 70 per cent. As the coal is very friable, it would be of little use to separate the fine stuff by screening at the mines, as a great deal would be again formed during transportation and handling. In Russia, at present, this preference for lump coal goes to the extent that, with hard anthracite, everything less than four inches in diameter is thrown aside as worthless.

With coking coal the friable nature is not so objectionable. The fine stuff of semi-bituminous, non-coking coals might be made into artificial fuel, though, where I have seen it used, it burns well even without specially constructed grates. I think all the coals, at least all that I have seen, would require preparation on dressing machinery, especially if they are to be used for making coke.

In judging of the chance of selling coal in the ports of the Black Sea, I am of course governed by what I hear. English coals of different kinds are used there, and there is no reason why the Russian coals should not replace them, if they can be delivered at less price and of sufficiently good quality.

IRON ORES.

All that I know about the deposits of iron ore of the coal formation, seems to show that it would be unsafe to count on their continuity either on the dip or the strike of the formations, in which they lie. They are brown hematite and seem to be altered carbonate of iron, which originally replaced limestone. The better ones contain 40 to 50 per cent. of iron, 7 to 20 per cent. of silica, 0.03 to 0.07 per cent. of sulphur and 0.12 to 0.4 per cent. of phosphorus, besides lime and clay. I saw one deposit, on which the

peasants had been mining for a distance of ¾ of a mile while at other places the deposits had less than 100 ft. in length. On the continuation of three different ones I found by prospect shafts, 15 to 25 ft. deep, nothing but very small nodules of the same ore in an altered limestone and forming less than 1 per cent. of the entire mass. It is claimed that the ore in depth becomes solid, filling the entire mass of the vein. Of this I had no opportunity of convincing myself. One deposit, 3 to 3½ ft. thick with a dip of 30° to the north, on the continuation of which I had explored by two shafts with the above described result, had been opened on a length of 1400 ft. and had furnished to the New Russia Iron Company at Uzovo its total product, 1500 tons of ore, or a little more than 1 ton per foot of length on the strike. It was worked out to a depth of 15 to 20 ft. measured on the slope, pillars of limestone 3 ft. in diameter remained standing and some of the pieces of ore were composed of a core of carbonate of iron surrounded by porous brown hematite. The whole coal formation contains many of these deposits and possibly better ores than those I saw. At Grushefka, coal vein No. 4 is overlain by red hematite of 2 ft. 4 in. thickness, forming a very hard good roof, which is left standing as plenty of iron ore is found in the neighborhood. At Gorlofka, 4 miles south of Nikitofka, on Mr. Polakof's property, a vein of iron ore, which at a depth of 30 ft. was of good quality and 3 ft. thick, proved, on being cut at a greater depth, to consist of only a few very thin seams. Near Petrofsky (see Iron Works) a Russian engineer sank on a vein of brown hematite and found the ore changed to carbonate of iron at a depth of 60 ft.

The peasants generally mine the ore themselves. Those who supply Hughes's works, haul it from various properties lying 14 to 33 miles from the furnaces. They mine in a primitive manner, nowhere over 30 ft. down on the dip of the veins, use no timber, and allow the openings to cave in. Hughes did not seem to have a large supply of ore on hand. He told me that in bad weather in winter the peasants' supply sometimes failed him, and he was obliged to take the blast off his furnace for several days. His consumption of ore was small, the production of pig iron being but 200 tons per week. There was not, when I was there, demand enough for steel or iron to

keep more than one furnace in blast. He told me that he could not compete far north on account of the cost of transportation, and that he had no outlet to the south, as the railroad stops 40 miles short of Mariupol.

Besides the iron ores of the Donetz basin, the nearest deposits that I have heard of are those of Korsak Mogila, 33 miles west of Berdiansk, a port on the Sea of Azof, and those of Krivoi Rog, which lies about 120 miles N. E. of Nicolaief.

Iron ores of Krivoi Rog (*Crooked Horn*). See Plate XV. A Russian engineer, who made a very careful exploration and survey of these deposits, estimated the amount of ore on the southern half of the basin down to water level to be 40,320,000 tons, containing, at 60 per cent., 24,192,000 tons of iron, and to a depth of 140 ft. below the river Inguletz to be 1,935,500,000 tons, or, with the same percentage of iron 1,161,300,000 of metallic iron. The veins pitch towards the sinclinal of the basin at angles of 45° to 60°; they are 7 to 40 ft. in thickness; one, vein No. 3, is said to be even 700 ft. thick, but, no doubt, contains intercalations. The outcrops lie 175 to 280 ft. above the river. The ravines cutting in from the Inguletz River and Saxagan Creek cross the formation and facilitate the exploration. In making the estimate, above mentioned, only so much of each vein was taken as could be traced north and south from each ravine, the intermediate greater portion being neglected. Vein No. 1, from 7 to 14 ft. thick, is said to have been traced on the outcrop for over 2 miles.

Samples were taken under the direction of Mr. John Fritz of the Bethlehem Steel Works at the points marked 1 to 8 on the plan, and analysed by Dr. F. A. Genth of the University of Pennsylvania. The ore is a fine grained specular iron ore, sometimes of remarkably regular stratification, changed near the surface to red hematite and limonite. It lies in quartzite, which is also very regular, and all intercalations are quartzite, with or without iron. Dr. Genth's analyses are given in appendix D. The whole basin lies in the granite formation of the Dnieper.

Iron ores of Korsak Mogila (*Korsak's Grave*). The exploration seemed not to have been made in a very systematic manner, so that it was impossible to decide whether the ore lies in regular veins, or irregular bodies, or what is the extent of each deposit.

The ore is found in a low ridge of quartzite, the highest points of which are about 200 ft. above the nearest water courses. In a prospect ditch of 150 ft. in length, I found deposits that looked like veins, one of 10 ft. the other of 4 ft. thickness and 60 ft. apart, pitching 75° west, the ore strongly magnetic, samples of which, analysed by Dr. F. A. Genth, gave the results shown in appendix D. I found no signs of explorations made to prove the extent north and south of these deposits. Mr. Nossof, who explored the ground in 1862, in a report, which I have read since my return to this country, speaks of the quartzite, in which the ore lies, as having penetrated the granite formation from below. His exploring ditches and shafts extend to a depth of from 7 to 21 ft. and show nothing but irregular deposits. A great deal of work would have to be done, before an opinion could be formed as to their extent or value.

A report that coal was found in the immediate vicinity of these iron ores arose as follows. About 9 miles to the north east of Korsak Mogila is the outcrop of a vein of hornblende schist 1 ft. thick, lying in granite, which was once reported as the outcrop of a vein of coal, probably in consequence of its dark greenish-black color. Three German miners, availing themselves of this appearance, sunk on the outcrop, filled their shaft, which was 5 ft. deep, with bituminous coal from the Donetz basin, broken in small pieces, poured dirty water upon it, then dug it out again and showed it to persons, who were interested in the supposed coal lands and in whose pay they probably were. The fraud was easily discovered, especially as the formation contained no sedimentary strata, in which coal might be contained.

Iron Works.

The government, though anxious to develop iron and coal industry, was not always very fortunate in its efforts. The first attempts in the south were made at *Lugansk*, the site being chosen probably because, though 16 miles outside of the coal fields, the river Lugan furnished power.

The Lugansk iron works were built in 1796, by Gascoin, a Scotchman. A man of the same name, who lived during the

reign of Peter the Great, worked the iron furnaces on the shores of Lake Onega, in the Olonetz District, 300 miles north of St. Petersburg, at the Petrosavolsk iron works. In Lugansk two blast furnaces with bloomeries were built originally. Gascoin made a few thousand puds of poor iron, using coke made of Lissitchansk coal, which yields but 30 per cent. of coke, and that of a friable nature. Lissitchansk lies on the Donetz River, 45 miles in a straight line N. 60° W. from Lugansk. Gascoin died about 1820. In 1830, another attempt was made, with like results. The iron was afterwards used for ballast in ships of war. In 1833, the blast furnaces were torn down and cupolas erected in their stead. Pig iron was brought from the Ural Mountains and anthracite from Grushefka, 200 miles south, for use in the foundry. After this time the works were only used for making ordnance for the Black Sea navy and fortresses. During the Crimean war 16 cupolas were in blast. At present some custom work is done for mines and railways, and agricultural implements are repaired.

800 mechanics and laborers are now employed. The capacity of the foundry is 8064 tons of small projectiles per annum. In 1879, with 1500 men and with 3 of the 4 cupolas always in blast, the value of the products was $1,500,000.

Iron works were first constructed at *Petrofsky*, in the western part of the coal fields, in 1856. Coke was procured from mines at two miles distance and ores from 20 miles to the southwest. In 1864, General Rachette, chief of the mining department at St. Petersburg, ordered a furnace of his pattern to be erected and as the Russian engineer in charge refused to construct it, not deeming it suitable for iron smelting, a German mining engineer was imported for that purpose. The furnace was put up in 1865 to '66 and, it is said, made some good iron. But owing to defective construction the lining gave out, the campaign lasting only 10 days. General Rachette hereupon declared that Petrofsky was in no respect the proper place for iron works, but that Lissitchansk was most favorably situated and it was immediately decided to build there. General von Helmersen seemed to be of the same opinion, as in 1873 he speaks of the place as one singularly favored by nature. To me it seems the last place in the coal fields for iron works. The ground is unfavorable, the coal is unfit for

making coke and there are no specially good ores in the vicinity. All the machinery was hauled on wagons from Petrofsky to Lissitchansk, no railways existing at that time in the coal fields. The works were commenced in 1867 and finished in 1869. The Rachette furnace was so modified that the inventor would not have recognized it. Its section was oval instead of rectangular, it had but 7 tuyères and instead of increasing in area from the boshes up it was drawn in in the usual way. The old mines were systematically opened and good hoisting and pumping engines put up. The metallurgist objected to use Lissitchansk coke, so the furnace was blown in with coke hauled from Golubofka, 20 miles to the south-east. It ran 3 weeks making 800 tons of pig iron and was then blown out, as the supply of coke was consumed. Two subsequent attempts were made to smelt, first with Lissitchansk coke mixed with coke made of coal of a better coking quality, taken from discoveries that were made 50 years ago and lying 10 miles from Lissitchansk, and with this coke and raw coal, but without success. About 40 tons of poor white iron were made and then operations ceased. The trials lasted 6 weeks; since then even the mines have been idle. The government not wishing to compete with individual enterprises, only raises enough coal for its own use and to work the pumps to keep the mines clear of water, for the benefit of the scholars of the school for mining bosses, which is established at Lissitchansk. A part of the practical course of these young men consists in working in the mines. The machinery which was put up at Lissitchansk had all been made at Lugansk.

The success attending the use of the Rachette form of furnace in copper smelting induced the inventor to have the same principle applied in iron furnaces, and among the first constructed was one at the Baranchinsky iron works in the north of the Ural mountains. It had 16 tuyères of 2¼ in. diam., 8 on a side. Gen. Rachette first intended to have double that number. From the bosh upwards the furnace increases in sectional area as shown in Pl. XVI. It worked with charcoal with a blast of 2 to 2½ in. of mercury. I could not obtain the dimensions of this furnace and give in Pl. XVI those of an improved one, which I take from Prof. Jossa's lecture on the present condition of pig iron industry in

Russia.* The first furnaces of this form worked very unsatisfactorily and at the suggestion of an engineer, the same who afterwards built the iron works at Sulin, experiments were made to determine the reactions taking place in different parts of the furnace. The trials were made at the Rayvola iron works in Finland; the furnace had 6 to 8 tuyères of 2¼ in. diam. and worked with pine charcoal under a blast pressure of 2 to 2½ in. of mercury. A small portion of the charge was placed in an iron vessel with perforated sides and having small compartments containing plugs of different degrees of fusibility. The vessel, attached to a gas pipe was allowed to descend with the charge to different points of the interior and a sample of the gas at each point taken for analysis before the vessel was withdrawn and its contents examined. The result showed that the proper reactions did not take place as in a well constructed round furnace and that the conditions varied very much at different points of the same horizontal cross section. A very serious practical difficulty presented itself in consequence of the enormous flame at the tunnel head, which prevented the men approaching near enough to charge properly.

The Rachette furnaces now in use have generally fewer tuyères than the one shown in Pl. XVI, sometimes only 3 on each side, and seem to work satisfactorily, though, I think, the Russian engineers prefer the round form.

Hughes's Works.—These works, mentioned on page 233 and 241, lie at Uzovo on a short branch of the Constantinofka Railway. They were built in 1870 to 1872, by the New Russia Company, composed of English capitalists, who obtained a concession to build a railway from Constantinofka on the Kursk-Kharkof-Azof Railway to Mariupol on the Sea of Azof, on condition of building iron and steel works on the line of their road. The company has two furnaces, each of a capacity of 200 tons of pig iron per week, and a much smaller one used for making ferro-manganese. At the time of my visit, Feb. 25th, 1880, this latter and one only of the larger ones were in blast. The four Siemens-Martin furnaces

* Extract of this lecture with cuts of different furnaces is given in *Dingler's polytechnisches Journal,* Vol. 239 (1881), p. 219.

were idle, as Mr. Hughes was only making wrought iron rails and merchant bars. All the machinery, iron buildings of rolling mill and iron work for furnaces, were brought from England. The plant is very good but the ground *seems* not very well chosen. the slag dump appeared 10 ft. higher than the ground on which the furnace stands. There is no casting-house or any shelter for the men that work at the blast furnaces. The coal mines are close to the works, and one vein furnishes coal out of which coke of excellent quality is made in ordinary clamps. It can be taken out of the clamps in columns as long as the full height of the charge (4 ft.), is very firm, has a metallic lustre and a bright, steel grey color. Mr. Hughes makes a very fine foundry iron with 0.5 to 0.6 per cent. of phosphorus. Some of his inferior grades I saw used at Lugansk for casting projectiles. His ores cost delivered R. 3.72 to R. 5.58 per ton, or average R. 4.65. Some of them contain a large percentage of manganese; they are all mined in the coal measures and, as mentioned above, not over 33 miles from his works.

Pastukof's Iron Works.—The only other furnace in the Donetz basin is at Sulin, in the anthracite region, 12 miles N. N. W. of Grushefka, and was built in 1869 to '70. The whole plant, including puddling furnaces and rolling mills, is admirably planned and the site well chosen. The machinery was brought from Belgium, as it was found, in spite of a very high protective duty, to be cheaper and better than that offered in Russia. During the first year anthracite from Grushefka was used, but afterwards the veins at Sulin furnished the fuel. The ores were mined at a cost of R. 2.17 ($1.08) per ton, including a royalty of 8 to 16 copeks, and were delivered at the furnace at a total cost of about R. 2.30 per ton. The coal cost R. 6.20 per ton, and 1.33 to 1.5 tons were required to produce one ton of pig iron. Two campaigns were made by the engineer who built the works, one of six and one of four months. Afterwards, the proprietor changed his engineers frequently, and but very short campaigns were made. In 1880, the furnace was not in blast, merchant iron being made out of accumulated pig iron, the former product of the furnace, and out of old rails.

An effort was made to combine the construction of a steel rail

mill with the Kursk-Kharkof-Azof R. R., connecting Kursk with Taganrog, but without result. The concession for this road was granted with the condition that steel works should be built on its line in the coal fields. After the completion of the road the engineers, who were to take charge of the different departments in the new work, did not agree entirely with the gentlemen who had obtained the concession, and as Mr. Hughes was then constructing his works at Uzovo, the former made this a plea for asking that he might defer the construction of his own works until after Mr. Hughes's enterprise had been successfully established, that he might profit by the experience gained there. The request was granted in 1869. Mines were opened at Gorlofka, four miles south of Nikitofka in the same year, but, though Mr. Hughes's works have been in blast since 1871, no steps had been taken up to 1880 to put up steel works.

Building Materials.—The limestones of the coal measures contain a very slight trace of magnesia and furnish an excellent lime. Mr. Hughes, who at first used fire-bricks brought from England, now makes them from clay found not very far from his works. Some of the sandstones furnish flags 3 and 4 ft. square and 1½ in. to 2½ in. thick; others, good building stones of over a foot in thickness, with smooth parallel surfaces, while others furnish very good millstones.

With the exception of the river bottoms and some of the ravines, the coal fields are entirely treeless. The timber is oak, small and crooked. Large, straight timbers, especially pine, are brought from the Dnieper river, and cost at present about $10.00 a thousand at the mines. The best point to establish saw-mills would be at Ekaterinoslaf, immediately above the cataracts of the Dnieper, 193 miles from Debaltsevo, the central junction of the Donetz railway. These cataracts extend from Ekaterinoslaf to Alexandrovsk, a distance of 45 miles, and the depth of water on them in the spring, the time of shooting the rapids, governs to some extent the price of lumber at Kherson at the mouth of the Dnieper, the present great lumber market of the south of Russia.

In the year 1870, before communication by rail existed between the Dnieper river and the coal fields, the engineer, who

built the iron works at Sulin, bought and cut down part of a forest near Solikansk, on the upper Kama river, 114 miles north of Perm, made up rafts composed of timbers 35 ft. long, and had these towed down the Kama and Volga rivers to Tsaratsin, thence transported by rail a distance of 48 miles, to Kalatch on the Don, made into rafts again and towed down to Rostof, again loaded upon cars and transported 78 miles to Sulin, costing him delivered $10.00 per 1000 ft. board measure. The total distance is 1600 miles. The logs were sawed into boards by hand. Labor was so cheap that the total cost of sawing was only 1 ruble (51 cts.) per 1000 superficial feet.

Labor. As far as I have been able to observe, the Russian workmen are not wanting in intelligence and seem apt at learning anything. The complaint that they shirk may be well founded, though I doubt if they are worse than Englishmen, or, at least, than Welshmen and Cornishmen. At Hughes's works they were accused of want of judgment as puddlers. The ordinary peasant is probably lazy, and, as his wants are few, he can afford to be independent, but almost every kind of work expected of them can be done by contract. They certainly are not afraid of exposure to severe weather. I saw them hauling coal and forage on one occasion, they walking in the snow next to their oxen, or horses, when the thermometer stood at —13° F. and a strong wind was blowing. Those that I saw in the summer in the villages along the north shore of the Sea of Azof seemed in much better condition than the peasants farther north. The houses were kept scrupulously clean, and there was an air of thrift and comfort, which showed that the inmates were well off.

The wages given on Appendix E. are about the same as those that rule throughout the coal fields, but they would advance very much in case of such an increased demand for labor, as would result from the starting of any large enterprise.

The low price of wages seems to lead to methods of work, that are not economical. For instance, at Lugansk the anthracite coal and pig iron is carried in arms of the workmen up a flight of steps 9 ft. high and thrown into the charging door of the cupola. The projectiles are carried from one building to the

other over a distance of several hundred feet in the arms or aprons of laborers. Then at Rostof on the Don, where I saw a small steamer loading grain, a laborer carried each sack from the wagon to a fan, such as our farmers use, and emptied the contents into the hopper. A second man turned the fan, while a third shovelled the grain from the ground into a sack, held by a fourth, who threw it, when full, on the back of a fifth, who carried it on board the steamer. Wagon, fan and steamer were about on the same level and 50 to 100 ft. apart. The railway terminus both at Rostof and at Taganrog is on the opposite side of the city from the wharves.

School for Foremen at Lissitchansk. This is similar to the "Bergschulen" in Germany. The young men, generally sons of miners, receive theoretical instruction during three and a half hours in the forenoon, when they are physically and mentally fresh, and the afternoons are spent at work in the mines and shops. The course requires four years and comprises instruction in writing, arithmetic, Russian language, religion, history, geography, drawing, geometry, algebra, descriptive geometry, trigonometry, surveying on the surface and underground with practice in same, physics, chemistry, mechanics, mineralogy, geology and mining. Lissitchansk is the oldest mining town in the Donetz basin. Coal having been mined there as early as 1791, and this is probably the reason why it was chosen as the site for the school and also for the government iron works. These and the mines cost the government over a million of rubles and were offered for sale in 1880 for 120,000 rubles.

While at Lissitchansk I was shown a specimen of the iron from the anvil block of the great steam hammer of Perm. The hammer weighs 50 tons, the steam cylinder has a diam. of 5 ft. and a stroke of 10 ft. With over steam the effect of each blow is estimated at 3280 foot tons. The anvil block weighs 564.5 tons. It was cast from 8 cupolas in 24 hours, and remained liquid 6 weeks, during which time iron was added as it shrank. It required 9 months to cool. It was cast with trunnions by which it was raised and turned lower side up. The specimen had been broken from the block and was remarkably soft and tough, owing, no doubt, to the long time it was cooling.

Railroads and Ports.

The government has deemed it more economical to grant liberal concessions to private individuals while furnishing a great part of the necessary capital than itself to undertake the construction of railroads.

Kursk-Kharkof-Azof R. R., built about 1870. The government took the whole mortgage covering the total cost and one-fourth of the stock, leaving three-fourths to the company, and guarantees 5 per cent. interest per annum on the mortgage, whether earned or not. The road to *Odessa* was built under similar conditions.

Donetz R. R., built about 1874–76. The government took all the mortgage bonds and five-eighths of the stock, leaving the company three-eighths. One-eighth was afterwards hypothecated with the government, so that it now owns all the bonds and three-fourths of the stock.

In the case of the *Constantinofka line* the government not only paid more per mile than the amount, at which the company let the contract, but, to aid the enterprise, graded the entire road from Elenofka, the present terminus, to the port of Mariupol with Turkish prisoners during the war of 1878, and found, to its cost, that it would have been cheaper to hire native labor. The distance is 60 miles. Mariupol was settled by Greeks, one hundred years ago, and now contains 8000 inhabitants. It is difficult to understand why it should have been chosen as the future terminus of the Constantinofka R. R. The Kalmius river forms a good harbor for *small* boats, but vessels drawing 14 ft. have to lie off 3 to 4 miles from the town. Even the steamer, in which I came from Taganrog, drawing but eight feet of water, could not approach nearer than 1½ miles from the shore. In spite of this difficulty, 5,700,000 bushels of grain were shipped from Mariupol, out of 48,000,000 bushels that left the ports of the sea of Azof in 1879. The natural terminus for this road is Berdiansk, a town of 15,000 inhabitants, founded in 1827, the best port on the north coast of the sea of Azof, and only 90 miles from Elenofka. A spit of sand protects it on the east and a breakwater, 1500 ft. long, has been constructed about half a mile from the shore. The pier is 500 ft.

long, with 10 to 12 feet of water at its head. Vessels begin loading by having grain carried aboard in bags and emptied, and finish by loading from lighters, from which the grain is taken in baskets.

The most important port of the sea of Azof, Taganrog, with 50,000 inhabitants, has, owing to the bars at the mouth of the Don, the same disadvantage as Mariupol in a greater degree, large vessels having to lie 15 to 25 miles from the town. The depth of water in the harbor is 9 ft.

Rostof on the Don has as large a foreign trade as Taganrog, but is obliged to ship its exports in barges or lighters to the Taganrog roadstead. Half way between Taganrog and Mariupol, at Krivaya Kosa, a depth of 14 ft. of water is found at 2000 to 2,500 ft. from the shore. But a few fishermen live there, no town has sprung up, as there is no natural harbor. The depth of water in the straits of Kertch or Yenekali, south of Berdiansk is 18 ft., and the greatest depth of water in the sea of Azof is 40 feet.

The railroads in the south of Russia are well built, with steel rails even on the sidings. The guage is 5 ft. all over Russia. The rolling stock is similar to those in the rest of Europe, the cars having very long wheel bases, with either 2 or 3 axles, and are necessarily destructive to the track and to themselves. Trucks are not in use. Trains are run on a side track at the stations, necessitating two switches and their attendants. In laying out the roads it seems as if too much stress had been laid on keeping the same level without regard to the cost of grading, or length of track. In one instance on the Donetz road a very long curve is made to avoid a slight depression, though freights are carried both ways. In other cases it seemed as if a cut in the side hill could have been made half cut half fill without disadvantage to the trace of the road. So north of Moscow, on the way to St. Petersburg, the road is laid in a cut which for 3 miles is 25 feet deep. And this is the more astonishing as in most instances the cut is wasted and the fill is borrowed. Only in very deep cuts and high embankments, when near to each other, have I seen this avoided. The cause may be owing partly to the fact that the earth work is done by the peasants with their small carts and wagons.

The duty on railway supplies is as follows:

Rails, iron or steel, ...	$18.00 per ton
Iron castings, without finish, . . .	20.00 " "
Tires and axles of iron, ...	47.00 " "
Tires and axles of steel, ...	64.00 " "
Locomotives, ...	31.60 " "
Platform and coal cars, ...	48.40 per axle
Freight cars, ...	70.70 " "
Second class passenger cars, . . .	144.60 " "
First class passenger cars, ...	208.86 " "

To foster home industry still further the government will not permit the importation of railway supplies unless it can be shown that the native works are unable to furnish what is required. And that all requisitions are closely scrutinized is shown by the fact that in one instance, when a railway company asked permission to import large and small locomotive wheels, the question was asked why they wanted a greater number of the former than of the latter, and the request was not granted until the directors had explained that the small ones wear out faster than the others.

Unsuccessful efforts were made by the French company, having mines at Rutchenkovo, to obtain a concession to extend their road east and west. It would probably have passed a short distance north of Berdiansk, with a branch to that port, thence to Korsak Mogila, thence to a junction with the Lozovo-Sebastopol Railway. This is a much needed connection and, with a greater spirit of cooperation than is now manifested, would furnish a good outlet for the Donetz and other roads. Another line was to connect Kurakhofka with Ekaterinoslaf and, passing thence to the Krivoi Rog ore deposits, form a junction with the Nicolaief Railway. At Debaltsevo, the central station of the Donetz road, we found fifty locomotives, most of them new, some that had never been used, nearly as many more out of repair, and about one hundred cars, half of which were used as lodging houses for the men. It was certainly not for lack of equipment of this road that the mines could not have their coal transported.

Grain, etc.

Better facilities for handling grain would probably stimulate the production and shipment. It is not carried in bulk in the

cars, and elevators are unknown in the south. The amount exported from Odessa in 1879 was 22,000,000, fell, however, to 9,000,000 in 1880. Nicolaief shipped about the same as Odessa, making the total from these ports and those of the Sea of Azof over 90,000,000 of bushels for 1879. The country is capable of producing much more than is now grown. In the coal fields the peasants have so much land at their disposal, that they change the portions sown from year to year. They as well as those on the north shore of the Sea of Azof make up the straw and manure into bricks which are dried and used as fuel, none of it coming on the fields. This is the case even on estates, on which coal mines are opened, a mile or two from the villages. The implements used by the peasants of the coal fields are of the crudest kind, but made with skill. The ploughs, some of which require eight oxen to draw them, are made entirely of wood, with the exception of the ploughshare. Their wagons have no iron, not even so much as a nail. The wheels are 24 to 28 in. in diameter. The rim is 3 in. wide and 1½ in. thick, bent into shape, the ends butting together between two of the spokes, without any connection. The hubs are light and 16 in. long. The peasants prefer to use wood, wherever it is possible, as they can make all repairs themselves. Near the Sea of Azof they seem better off, their wagons, at least, would compare favorably with those used in the north of Germany.

On the large estates improved agricultural machinery has been introduced, such as reapers, thrashing machines and portable engines, both American and English. At Zuefka in the coal fields Mr. Illovaisky, whom I have already mentioned, established a foundry and machine shop on his estate; the repairs of farming implements and construction of machinery for his farm, distillery and coal mines being sufficient to keep a number of mechanics busy. In one year he sowed 32,800 acres of land in wheat.

In addition to the careful survey and exploration of the Donetz coal fields by Russian engineers, the government sunk an artesian well near Bakhmut, a station on the Donetz Railway, lying 27 miles south-east from Slaviansk, which latter place had long been noted for its saline lakes. At a depth of not over 700 ft. a

bed of pure rock-salt was struck and the drill penetrated through 150 ft. of it without reaching the floor of the deposit. Considering the liberality of the government in making these investigations and the favorable conditions, which it is inclined to grant individuals as an inducement to undertake enterprises which will contribute to the development of the south, it is difficult to understand why it should have refused the concession for a pipe line to connect the Caspian and the Black Seas. The shores around Baku on the Caspian Sea, as well as the islands opposite, are said to abound in petroleum. An American, who owns an oil refinery at Taman, near the Straights of Kertch, proposed to lay a pipe line from Baku to Poti on the Black Sea. The distance is 690 versts, or 460 miles. The pass at Suram in the Pensat Mountains, which form the divide between the two seas, is 2191 ft. high. A railway now crosses it, connecting Tiflis with Poti. The American asked that no other line should be laid within 16⅔ miles on either side of his. The concession was not granted and the ports of the Black Sea and the Mediterranean have no immediate prospect of drawing their supply of coal oil from the Caspian. Great as the advantages to the American capitalist might appear, they would be small compared with those to be derived by the Russians themselves by such an enterprise. The tolls could be fixed and the security asked does not seem excessive for foreigners in an undeveloped country.

APPENDIX A.

Cost of Mining on two Veins at Yastchikovo. Upper Vein 2½ ft., Lower Vein 4 ft. Thick.

The wages, upon which the following estimates are based, are:

Coal cutters and trammers, including oil for lamps,	R. [illegible]1 per day.
Fillers,	0.96 "
1st foreman or superintendent,	R. 125 per month.
Book-keeper,	45 "
Foreman,	50 "
Engineer,	25 "
Stokers,	20 "
Machinist, for repairs,	42 "
Blacksmith and helper,	45 "
Laborers,	15 "
Teamsters,	15 "
Bricklayer and carpenter, for repairs,	each, 1 rouble per day.

For a production of 100,000 puds (1613 tons) per month of twenty-two days, from each vein, I estimate the cost of the coal as follows:

	COST PER TON OF COAL. Upper vein.	Lower vein.
Cutting and tramming, wages and oil,	118.916 cop.	90.520 cop.
Hoisting and pumping,	31.930 "	31.930 "
Timbering,	16.864 "	10.292 "
Wear and tear of machinery and buildings,	12.958 "	12.958 "
Teamsters and teams,	4.960 "	4.960 "
Incidental expenses,	6.200 "	6.200 "
Cost of galleries,	14.446 "	16.182 "
Screening, etc., of coal,	6.944 "	6.944 "
	213.218 "	179.986 "

Average for both veins,	196.602	copecks
1 superintendent, 1 bookkeeper, 2 foremen, watchmen, and office expenses,	12.090	"
General expenses for 1 chief engineer, 1 asst. do., 2 bookkeepers, 3 clerks, government surveyor, selling agent, and office expenses, divided between the three estates, Yastchikovo, Mikhaïlovka and Volyntsevo, for a production of 350,000 puds (5645 tons) per month,	18.414	"
Total cost of 1 ton of coal at the mine,	227.106	"
Transportation on narrow guage railway,	17.670	"
Government tax,	6.200	"
Expenses (charges) at Donetz R. R. office,	1.240	"
Cost of 1 ton of coal on cars of Donetz R. R.,	252.216	"

Or a little over 2½ rubles, exclusive of royalty to owners of property and sinking fund for outlay for plant.

For a production of twice the amount, that is, for 6452 tons per month, or 293 tons per day, the cost would be about 2.08 rubles per ton, and, with greater development, working several seams from the same shaft, rather better means of handling, and application of improved methods of haulage (see App. B), the cost could, no doubt, be reduced still more. But a greater demand for labor would necessarily increase its price. The Russian is not stupid, and would soon know his value. At present, for instance, the cutters and trammers receive 26.40 rubles per month in summer, when there is work to be found elsewhere, while in winter they are paid but 18 rubles per month, or 30 per cent. less. The work is, of course, done by contract, but at the above rates. I therefore think that it would not be safe to count on producing coal for less than 2.50 rubles per ton, in places as favorably situated as Yastchikovo, and for narrower veins it may cost even more.

Extract from Mr. O. J. Heinrich's report on the Donetz coal fields:

* * * * * * * * * *

This Donetz district may, with regard to its seams, be compared with those of similar character on the continent of Europe, such as the basins at Worms, Ruhr, Saar-

brucken or Mons, and some of the French basins, and from such we must draw our experience to judge of the value of that district. To give the fairest show to those districts in Europe, we will take the time before the financial crisis, say 1872, in regard to amount of production.

Worms Basin.—30 seams workable, from 18 in.–3 feet, dip 12°, but very steep in the northern part.

Ruhr Basin.—First series of seams, near the bottom of the coal formation:—(1st.) 21 workable seems average 28 in.

(2nd.) or centre series of seams:—26 workable seams, average 40½ in.

(3rd.) or top series of seams:—29 seams, averaging 32 in.

All seams under 12 in.–18 in. not workable; the pitch averages from 40–60°, and even reaches 80°.

Saar Basin, Saarbrücken, Western Section.—157 seams; 84 not workable; the workable seams measure from 36 in.–48½ in., average of 84 seams, 38 in.

Eastern Section.—211 seams, 127 not workable. The workable seams, 84 in all, measure from 36½ in.–40½ in., averaging 42½ in.; from 10°–40° pitch.

Taking a few of the coal districts with thicker seams, in Germany, we have the Zwickau basin (Saxony); 5 seams, averaging 6½ feet, the largest sometimes 30 feet thick, from horizontal to 10° and 15° pitch, the thicker seams often much affected by parting slates and impurities.

Waldenburg Basin.—31 seams, of which

16 seams average 6 feet.
15 " " 33 " } at 30° pitch.

SILESIA.

Nicolai Basin.—26 seams, from 3½ to 7½ feet.

Zabrze Myslowitz Basin.—From 5½ to 19½ feet, at 5–80° pitch.

The production of these fields were:

BELGIUM IN 1876.

Mons Basin, 180 works produced 14,329,578 tons, or 79,608 tons per work.

GERMANY IN 1877.

1. *Worms.*—23 works produced 582,832 tons, or 25,340 tons per work.

2. *Ruhr Basin.*—373 works, of which, in Westphalia, 148 works produced 9,034,215 tons, or 61,042 tons per work.

Rhein Province.—225 works produced 14,430,965 tons, or 64,137 tons per work.

3. *Saar Basin.*—Nearly all Government works, standing at the highest grade of perfection. Nine works produced 4,680,716 tons, or 520,080 tons per work.

4. *Silesia.*—160 works produced 9,371,428 tons, or 58,571 tons per work.

These mines are very difficult to work, having much to contend with spontaneous combustion, and a great deal of timbering.

For further comparison, I add the production of Luzerne county, Pennsylvania, in 1878. Here 52 breakers produced 3,957,934 tons, or 76,114 tons per work; and, as one of the model colleries of the district, I give that of No. 1 Breaker, Cross Creek Colliery, in 1879: 1 breaker 250,614 tons in 268 days.

The total increase of production in Germany has been from 5,168,284 tons in 1850, to 12,347,828 in 1860, and 26,397,769 in 1870.

The number of men employed, and the amount of coal produced by one man per annum, will throw additional light upon the subject.

	Men employed.		Per man.
In the Mons Basin (Belgium), ...	108,543,	produced	132 tons.
" " Worms " (Germany), ...	3,956,	"	189 "
" " Ruhr " "	68,602,	"	200 "
" " Saar " "	22,903,	"	204 "
" " Zwickau " "	10,799,	"	211 "
" " Silesia " "	42,601,	"	220 "
" " Luzerne Co., Lehigh Basin, Pa., .	13,045,	"	313 "
" " No. 1 Breaker, Cross Creek Colliery,	471,	"	529 "

The supply of coal to aid materially in the profitable results of the enterprise must form a large and important factor. It will, therefore, be but reasonable to aim at once at a production per annum in proportion to such an enterprise. I, therefore, at the outset will say that 500,000 tons per annum for the first period of time, would be a minimum. Of course a prospective increase must at once not be lost sight of. From Mr. Vezin's report I take, as a sample, the Yastchikovo estate, which, according to his statements, comprises 3,190 acres at a prospective yield of 3,032 tons per acre, to a depth of 350 feet, or a total yield of 9,671,555 tons, provided that such regularity has been really proved to warrant those estimates. At the present time, to use modern improvements in coal mining to advantage, a yield of 500 tons per shaft plant per day is considered moderate. Allowing, on account of the many Russian holidays and possible stoppage on account of severe winters, 260 working days a year, this would give a product of 130,000 tons per shaft, and four such shafts plants would produce 520,000 tons per annum.

At a yield of 3,032 tons per acre, an area of about 42.8 acres coal ground would have to be cut per annum, and a linear distance per annum of 1,283 feet main roadways to be kept ahead for annual supply. Allowing a distance of one mile each side of the shaft, in 4.1 years that area would be exhausted and a sinking to a lower lift required. This lower lift to 700 feet would yield 7,133.7 tons per acre. Accordingly, it would require 18.2 acres per annum to supply the production, and for the same distance from the shaft it would require 9.4 years more to exhaust the ground, making in all 13.5 years for the use of the shaft plant to 700 feet depth.

From the figures given by Mr. Vezin, of the cost of working in Russia, and they appear to be very fair in regard to the difficulties necessitated by small seams, I would hesitate to put the cost of plant, driving entries and preparing self-acting planes to deliver the coal from the higher lifts to the main roadways, for one colliery of 500 tons per day, at less than:

For sinking shaft, putting up plant, including hoisting, pumping and ventilation engines, also necessary machinery for preparing coal, . .	$75,000
For 11,946 feet main road, gangways and inclines necessary to commence regular production, all done at dead expense (the coal being worth very little and much rock work to go through), to cost about, . .	21,000
Total, ...	$96,000
Incidental expenses, 10 per cent., ...	9,600
Total, ...	$105,600
Or for 4 collieries of that kind, ...	$422,400

To carry on such a production, at an average yield of 167 tons per man per annum, which is a fair estimate from my former statistics, allowing only 260 working days, it would require a force of 3,000 men, who would have to be supplied with houses, etc., which, according to Mr. Vezin's figures, at $250 each, allowing 1,000 houses, including families, would add $250,000. Therefore, with all other improvements necessary, $700,000 to $750,000 will not be too much. Allowing 10 per cent. to redeem the capital in ten years, and allowing for reserve and 6 per cent. legal interest upon the capital, this item will make 24c. expense per ton for coal.

The total cost of producing coal may therefore be estimated:

Cost of mining coal, as estimated by H. A. Vezin, all expenses due to mining, including labor, material, officers, mine transportation, etc., per ton of 2,240 lbs., @ 2.50 rubles (1 ruble=$.51),	$1.28
10 per cent. redeeming fund, and 6 per cent. interest upon investment of $750,000 for colleries, fixtures, buildings, etc.,	.24
Royalty per ton,	.15
Total per ton,	$1.67

APPENDIX B.

Haulage by Chains and by Wire Rope.

The improved method of haulage, referred to in Appendix A, I saw in use at the von der Heydt mine, four miles from Saarbrücken, in the south of Rhenish Prussia, and at Mariemont, near Charleroi, in Belgium. At the von der Heydt mine two systems are in use. One consists in the use of wire ropes with two engines, one at each end of the road; the other in an endless chain drawn by one stationary engine. There are two roads with wire ropes, one 5,709 ft. long, with ropes $\frac{5}{8}$ in. (15 mm.) diameter, the other 12,368 ft. long, with ropes of $\frac{3}{4}$ in. (18 mm.) diameter. When one engine is hauling the train, the one at the other end unwinds by letting its drum run loose with the break slightly set, so as to give its rope, which now acts as tail-rope, enough tension to prevent its dragging on the intervening ground between the rollers. The tracks have many curves in the adits, levels and crosscuts, in which they are laid. The wire ropes are of charcoal iron, the rollers of cast iron, and these latter are set inclined in the curves to prevent the ropes from jumping out. The train, which consists of 100 cars coupled together, each car holding $\frac{1}{2}$ ton of coal, is drawn at a velocity of 8 to $11\frac{1}{2}$ ft. per second, or 5.5 to 7.8 miles per hour. To each end of a train is coupled an iron guide car with a device to guide the rope on the rollers, which device is only in use on the car at the rear of the train. If the loaded cars are brought to the end of the track in the mine without delay, and they are unloaded promptly at the other end, 25 trains, carrying 1250 tons of coal, can be hauled

NOTE.—The reports consulted (as referred to above) are the following:

1. Der Anthrazitbergbau im Lande des Don'schen Heeres, von Seebold. *Preus. Zeitsch. fuer Berg., Huett. und Salinen.*, 1872.

2. Die Lage des Steinkohlenbergbaues im I. Bezirk des Westlichen Theiles des Donetz Gebietes, von Schnable. *Berg. u. Huett. Zeitung*, 1877.

3. Die Mineralschätze des europäischen Russlands, *Berg. u. Huett. Zeitung*, 1880.

All statistics are taken from Government Reports published in the above journals. O. J. H.

out in 10 working hours on the shorter line, and 15 trains, or 750 tons, on the longer one. A conductor accompanies each train. The levels and adits, passed through, are provided with a telegraph cable, in which at every 1000 ft. an apparatus for breaking the circuit is inserted. By pulling vigorously at the cable, the conductor can transmit signals, even when the train is running at full speed. These roads have been in operation for 20 years. Upon the arrival of a train at the mouth of the adit, the cars are pushed singly under the chains of two chain tramways. The length of each of these is 1738 ft., and each has a curve of 479 ft. radius, forming an arc of 168°. Sharper curves cannot be passed without releasing the car from the chain, as described below. The cars are placed at intervals of about 50 ft. and serve as supports for the chain, rendering rollers between the rails of the tracks unnecessary. The chain rests in forks which are riveted to one end of each car. These roads have been in use since 1872. The iron of the chains was originally ⅜ in. (10 mm.) in diameter, and has been worn down to ⅓ in. (8 mm.).

The principal chain tramway is in the Burbach adit, and delivers the coal to the same shipping point as those described above. The cars are hauled by horses to the underground terminus. The length of the road is 5773 ft., consisting of two straight lines connected by a curve of 81.4 ft. radius, forming an arc of 103°. To pass this curve the chain draws the cars up an incline, beyond the summit of which it passes around a guide pulley placed so high as to release the cars. This point of release is the beginning of the curve, laid on a grade, down which the cars run by gravity to take their places automatically under the chain in the new direction. The cars are about 50 ft. apart, as in the former case, so that 80 to 85 loaded ones and the same number of returning empty ones are always under the chain. It rests on the coal or on the edge of the car, its weight being sufficient to prevent slipping, so that forks are unnecessary. Each car holds ½ ton. This tramway, when I saw it in October, 1880, had been working uninterruptedly since September, 1874, with a capacity of 400 to 500 tons in 10 working hours. It could easily, at its regular speed of 4.1 ft. per second or 2.8 miles per hour, deliver 1250 tons in the same time. The chain is made of iron ¾ in. (20 mm.) in diameter. The inside length of each link, or the pitch of the chain, is 3 in. (76 mm.). The chain is wound 1½ times around the driving drum, which is covered with wood with a conical hollowed surface, on which the chain slips sideways as it is wound on the one side and off on the other. This wooden lagging costs $25.00, and lasts over a year before having to be turned off. The original lagging (of oak) was still in use when I saw it. A cast iron chain wheel sleeve would cost $75.00 to $100.00 and wear out in four months, and would have the objection that its teeth would not accommodate themselves to the increased length of links or pitch resulting from wear. The grain of the wood is not placed radially, as it would become too smooth, but as nearly as possible with the circumference. The chain showed very slight signs of wear. It sustains a tension of 2 tons. The driving engine, placed near the mouth of the adit, is connected with the drum by gearing, and is said to work with 7 indicated horse-power. The drum is 4 to 5 ft. in diameter. The same method of driving is used on the two short tramways. At the Burbach adit tramway the cars, just before being released, are drawn up a slight incline and then run by gravity down a short curve and over a bridge to the shipping point.

The roads with wire rope, as well as those with chains, are horizontal. The chief

engineer assured me that there would be no difficulty in overcoming grades of 14° to 15° (25 ft. to 26.8 ft. per 100) without the use of forks on the cars, though it might be necessary to have the chain rather heavier than the ⅝ in. one.

TOTAL COST OF HAULING PER TON PER 1000 FEET.

By horses, 1.5 cts.

YEAR.	TRAMWAYS WITH WIRE ROPE.				TRAMWAYS WITH CHAINS.			
	Length, 5,709 ft.		Length, 12,368 ft.		Length, 1,738 ft. (above ground).		Length, 5,773 ft. (in Burbach adit).	
	Amt. of coal hauled, tons.	Cost cts.	Amt. of coal hauled, tons.	Cost cts.	Amt. of coal hauled, tons.	Cost cts.	Amt. of coal hauled, tons.	Cost cts.
1872	262,035	0.58	112,880	0.52				
1875	265,317	0.46	20,278	0.62	287,057	0.71	115,671	0.20
1879	230,152	0.29	99,626.5	0.37	330,061	0.40	119,987	0.22

That is to say, hauling with horses would have cost 7 times as much in the Burbach adit as it did by chain in 1879.

At Mariemont, on the two properties Mariemont and Bascoup, both under the same management, chain tramways (trainages méchaniques) are used: those on the surface, for the purpose of connecting all the shafts of one property with its central shipping point, and those underground instead of horses. Shafts that are practically inaccessible by railways are thus enabled to ship their coal virtually as cheaply as those favorably situated. The chains, varying from ⅝ in. to 1⅛ in. (16 mm. to 28 mm.), according to the strain to which they are subjected, rest in forks, which are riveted to the front end of each car. The tracks (2 ft. gauge) run up and down hill with maximum grades of 20 ft. to the 100. The driving wheels for the chains differ from those at the von der Heydt mine. Instead of the wooden drum, a disk is used of about 2 ft. to 2½ ft. diameter, carrying forks that seize the chain. These forks are of iron or steel and form the heads of long, heavy screws lying radially in the disk. As the length of the chain increases in consequence of wear, these forks are screwed out as many half turns as are necessary to give the wheel the proper pitch. Whenever the chain becomes so long as to drag on the ground between cars 50 ft. apart, it is shortened. The Mariemont property, with an annual production of 500,000 tons, has six large shafts connected by tramways with the shipping point, which is near one of them. The total length of the tramways on the surface is 17,187 ft., and underground 13,452 ft. The longest single one on the surface, 3,904 ft. in length, transmits the product of its own shaft and that of two others, one of which is 6,923 ft. from the shipping point. At the point of transfer the cars are guided by hand from one chain to the other.

The 16 workable veins vary from 14 to 39 in. in thickness, and are worked at depths of from 1017 to 1939 ft.

The property of Bascoup has 8,694 ft. of chain tramways on the surface and 16,405 ft. underground. There are 19 veins, varying from 15 in. to 67 in. in thickness, and worked at depths of from 689 to 2001 ft.

The chains on the surface roads are driven by stationary engines; those underground by: (1) underground engines, (2) engines above ground with transmission of power by wire rope, and (3) by the surplus power of inclined planes underground, the power of the descending loaded cars being much more than sufficient to hoist the empty ones. In one case I saw such an incline working two horizontal chain roads, each of 500 ft. in length. In another the loaded cars are drawn from the bottom of a small basin over a saddle and then descend a slope, the upper portion of which has an inclination of 28°, which changes in the middle portion to 22° and in the lower part to 14°. At each of the points, where the change of inclination takes place, a weighted roller prevents the chain leaving the fork, and is raised about an inch as the car passes under it. The roads have no curves.

The coal is loaded in the cars, where it is cut, and transported in them to the shipping point, where it is dumped upon movable screens (Briart's system) and loaded into railway cars, the larger sizes undergoing picking on revolving sorting-tables. A description by Mr. Wetekamp of the methods of mining, man engines, pumping engines, tramways and machines for loading lump coal gently to prevent breaking it, may be found in Vol. XXIX of *Zeitschrift für Berg- Huetten- und Salinenwesen* (1881). When in Mariemont, in January of this year, I was told that a pamphlet with illustrations was to be issued, giving descriptions of the mines and their mechanical devices, the results of work, cost, etc., but I think it has not yet appeared.

APPENDIX C.

PRODUCTION OF COAL IN THE DONETZ BASIN IN 1879.

From the report of a meeting of owners of coal mines, held at Novotcherkask. 1 ton=62 puds.

The second and third columns give the quantities of coal at the mines and stations awaiting transportation on Sept. 1. In consequence of the constant complaints of mine owners, that they could not obtain sufficient transportation for their coal, and the reply of the railway companies that the necessary means were always ready, but that the mines could not produce more coal than was then brought to the markets, the association of mine owners ordered a report to be made of all accumulations on hand on a certain day.

Names of Railways near which the mines are situated.	Production in 1879. Tons.	On hand Sept. 1, 1879. at the mines. Tons.	On hand Sept. 1, 1879. at the R. R. station. Tons.	Estimated production for 1880. Tons.
Kursk-Kharkoff-Azoff R. R., 16 mines .	239,564.5	22,500.0	95,000.0	411,290.3
Constantine R. R., 19 mines	291,693.5	43,306.5	23,387.1	625,806.5
Donetz R. R., western part, 45 mines . .	422,418.4	45,809.7	24,596.8	783,871.9
" " eastern part, 31 mines . .	158,548.4	46,871.0	21,112.9	380,645.2
Koslovo-Voronej-Rostoff R. R., 17 mines .	435,483.9	52,838.7		637,096.7
Total for R. Rs. of Donetz Basin, 128 mines.	1,538,709.7	213,325.9	164,096.8	2,838,709.7

NOTE—Of the 128 mines in the Donetz Basin, 110 were producers in 1879; 76 had coal accumulated at the mines and of these 49 had also accumulations at the R. R. stations on September 1, 1879, awaiting transportation.

ESTIMATE OF CONSUMPTION OF DONETZ COAL IN 1880.

The figures are furnished by the consumers. The government prescribes that the requisitions of consumers shall be filled in the following order: first, railroads; second, sugar houses and sugar refineries; third, factories, mills, machine shops; and fourth, public works and private individuals.

Railroads:		
Including the Kursk-Kief and Moscow-Kursk, 11 in all; of these, 4 require, of anthracite	145,161.3 tons.	
and all the 11, of bituminous, .	397,983.9 "	
		543,145.2 tons.
Sugar-houses and sugar-refineries:		
In the Fastof region, 15 consumers, ...	66,129.0 tons.	
In the Soumy region, 14 consumers, ...	66 129.0 "	
In the Azof region, 2 consumers,	11,290.3 "	
		143,548.3 "
Manufactures, Mills, Machine Shops, &c.:		
(*a*) In Kharkof and along the K. K. Azof R. R., 21 consumers, . .	28,629.9 tons.	
(*b*) On the line of Lozovo-Sevastopol R. R., 19 consumers, . . .	16,129.0 "	
(*c*) Line of Kharkof-Nicolaef R. R., 12 consumers, ...	18,629.0 "	
(*d*) Line of Moscow-Kursk R. R., *City of Moscow: bituminous, 64,516.1; anthracite, 16,129.0,	80,645.1 "	
(*e*) Line of Kursk-Kief R. R., 3 consumers in Kief, including 1 sugar refinery, ...	11,290.3 "	
Total for manufactures, mills, machine shops, &c., . . .		155,322.4 "
Public Works, Private Consumers:		
Gas works at Kharkof, Taganrog and Rostof, ...	9,677.4 tons.	
Waterworks in Kharkof and Ekaterinoslaf, ...	2,419.3 "	
Steamers on the Dnieper, Volga, Don and Black Sea, 6 consumers, .	35,483.9 "	
Navy-yard in Nicolaef, bituminous, 8,064.5; anthracite, 16,129.0, .	24,193.5 "	
Government rifle factories in Tula and Biejetzk, bituminous, 11,290.3; anthracite, 8,064.5, . .	19,354.8 "	
Private individuals in 15 large towns and other small ones both bituminous and anthracite, . .	517,741.9 "	
		608,870.8 "
Total		1,450,886.7 tons.

* The actual wants of factories, mills and machine shops in the city of Moscow are estimated at 1,096,774 tons.

APPENDIX D.

The following analyses were made by Dr. F. A. Genth, of the University of Pennsylvania:

Samples of Ores from Krivoi Rog.

No. 1.—Most of the pieces were a compact, more or less hydrated hematite. Visible width of vein, 10 ft.

No. 3a.—Compact, red and reddish black, slightly magnetic hematite, also some slaty hematite. Samples 3 and 3a represent 60 ft. in length on the same vein.

No. 4.—Reddish iron-black, somewhat laminated, slighly porous hematite. Sample was taken from pieces of "float" over a width of 60 ft., the outcrop not being visible.

No. 5.—Purplish-red, somewhat porous laminated hematite. From a vein showing 10 ft. in thickness exposed.

No. 6a.—Yellowish-brown and brown, somewhat siliceous, more or less porous limonite. From 16 ft. in width of same vein as No. 6 taken from float on outcrop.

Samples 1, 3a, 4, 5, and 6a, contained:

	From	To	Average.
Ferric oxide,	96,111 per cent.	72.924 per cent.	85.940 per cent.
Ferrous "	1.221 "	2.867 "	2.134 "
Manganic "	0.041 "	0.103 "	0.078 "
Alumina,	0.138 "	1.563 "	0.950 "
Magnesia,	0.043 "	0.100 "	0.070 "
Lime,	trace	1.410 "	0.508 "
Titanic acid,	none	0.120 "	0.032 "
Phosphoric acid,	0.064 "	0.421 "	0.205 "
Silicic "	1.490 "	13.140 "	6.344 "
Sulphur,	none	0.037 "	0.014 "
Water,	0.960 "	8.920 "	3.840 "
			100.115 "
Metallic iron,	53,194 "	68.228 "	61.818 "
Phosphorus,	0.028 "	0.184 "	0.089 "

No. 2.—Compact, somewhat cavernous, slightly hydrated hematite. Sample taken from a visible width of 40 ft.

No. 3.—Compact, somewhat slaty hematite. 10 ft. in width of vein visible where sample was taken.

No. 6.—A siliceous, yellowish-brown limonite, with a considerable admixture of quartz. Sample from 40 ft. in width of a vein that is said to be 700 ft. thick.

No. 7.—Brown porous limonite. Sample of across 30 ft. on the surface of a vein to the north of No. 6. Principally float.

No. 8a.—Fine scaly laminated hematite. On Inguletz River, opposite Helmersen's mill. The ore here forms a steep cliff. The sample was taken across 20 ft. of the vein, which contain 4 or 5 ft. of intercalations.

No. 8b.—Similar to 8a but more siliceous. Sample of the 4 or 5 ft. of intercalations contained in the 20 ft. of vein, sample 8a.

Samples 2, 3, 6, 7 and 8a contained:

	From	To	Sample 8b contained:
Metallic iron,	45.265 per cent.	36.179 per cent.	37.500 per cent.
Silicic acid,	28.080 "	44.730 "	45.790 "
Phosphorus,	0.005 "	0.127 "	0.003 "

Samples of Ores from Korsak Mogila.

No. 51.—Sample No. 1.

The sample consisted of three kinds of ore, viz.: a friable granular, highly magnetic, black ore; a more compact, shining, brownish-black, magnetic ore, mixed with limonite; and compact hematite. The whole sample, reduced to powder, contained:

Ferric oxide,	79.296	per cent.
Ferrous "	15.718	"
Manganic "	0.093	"
Alumina,	0.967	"
Magnesia,	0.598	"
Lime,	0.280	"
Titanic acid,	0.060	"
Phosphoric acid,	0.043	"
Silicic acid,	1.200	"
Sulphur,	0.059	"
Water,	2.200	"
		"
	100.514	"
Metallic iron,	67.732	"
Phosphorus,	0.019	"

No. 52.—Sample No. 2.

Mostly a granular, black, highly magnetic ore, mixed with limonite, also some more compact ore. The whole sample gave, on analysis:

Ferric oxide,	82.855	per cent.
Ferrous "	10.195	"
Manganic "	0.093	"
Alumina,	1.452	"
Magnesia,	0.389	"
Lime,	0.570	"
Titanic acid,	0.080	"
Phosphoric acid,	0.015	"
Silicic acid,	2.050	"
Sulphur,	0.118	"
Water,	2.640	"
	100.457	"
Metallic iron,	65.928	"
Phosphorus,	0.007	"

APPENDIX E.

Wages and Cost of Living at Lugansk in 1880.

The day's labor is 10 hours actual work. For Sundays and holidays 50 per cent extra is paid. Most establishments post a list of those of the 100 annual holidays for which they agree to pay extra. The manager of the Lugansk Works gives the total number of ordinary working days in the year at 275.

Wages.—Laborers, 40 copeks per day.

Mechanics, 0.60 to 1.50 rubles per day. By piece work they sometimes earn as much as 3 rubles per day.

Moulders, 0.80 to 1.50 rubles per day. They usually work by the piece, in which case they may earn as much as 3 rubles per day.

Blacksmiths, 0.75 to 1.20 rubles per day.

Helpers, 0.50 to 0.60 rubles per day.

Patternmakers, 1.50 rubles per day.

Carpenters, 0.75 rubles per day.

Engineers, 25 rubles per month.

Stokers, 15 to 18 rubles per month.

At the Iron Works at Sulin, 12 miles northwest from Grushetka, the engineers of the blowing engine receive each 55 rubles per month, with fuel and quarters (two rooms). No allowance made for Sundays or holidays. These men erected all the machinery themselves. They came from Lugansk. Their work was as good as if done by the machinists, whom the builders of the engines proposed sending to erect.

Cost of Living.—The workmen generally own their own houses, which are roomy and comfortable, and cost 300 to 500 rubles each.

Each house is taxed 40 to 60 copeks per annum, the village tax.

Furniture for such a house costs about 40 rubles, i. e., 2 beds, 6 chairs, 1 table, 1 sofa, and the kitchen utensils and furniture, including a few chests, all of simple pattern.

Cost of Provisions.—A family consisting of husband, wife, and two children can purchase the necessary food for 50 copeks per day.

Meat, 8 copeks per lb.

Rye flour, 1.80 rubles per pud (= 36 lbs.).

Wheat flour, 2.40 rubles per pud.

Potatoes, 0.70 to 1.50 rubles per 60 lbs. (1⅔ puds).

Sugar, 7.60 rubles per pud, 19 copeks per lb.

Tea, 1 to 2 rubles per lb.

Coffee, 0.50 to 0.70 rubles per lb.

Butter, 10 to 12 rubles per pud, 25 to 30 copeks per lb.

Sweet oil, 6 to 8 rubles per pud, 30 to 40 copeks per quart.

Board for an unmarried man in a family, 12 rubles per month. Bedding sometimes furnished.

When 10 or 12 workmen mess together, board, including rent, costs them 7 to 8 rubles per month per man, the men finding their own bedding.

Rent, on an average for an unmarried man, 3 rubles per month.

XV.

WIRE ROPES.

By Dr. H. M. Chance, Member of the Club.

Read April 2d, 1881.

Iron Wire Ropes were first successfully used in the mining region of the Hartz about the year 1836.

The advantages of iron or steel wire over hemp ropes were thoroughly proven as early as 1837–1840, but they were not extensively used until some years later.

These advantages are:

1. Greater durability.
2. Less weight for equal strength.
3. Reduced cost per ton of material raised.

The same essential advantages can also be claimed for wire ropes over chains or flat bands of iron or steel.

A series of figures given by Taylor,—"Statistics of Coal,"—show that the cost per ton of material raised with hemp rope is about three times that of wire rope: the data furnished show an average cost of 1.30 cts. per ton in the former and only .36 cts. in the latter case. These figures apply to shaft collieries only,—in slope collieries the difference would be greatly increased by frictional wear on the bearing pulleys.

In our anthracite mining regions the cost of rope per ton of material raised is subject to great variations, depending,

1st. Upon the depth,

2d. The working load, and

3d. Upon the diameter of sheaves, drums and pulleys.

The following table shows the tonnage raised by twenty-three wire ropes used at eleven different slopes on dips ranging from fifteen to sixty degrees; and the tonnage of six ropes at three shaft collieries. Nearly all of these ropes were made by the Roebling company; are of seven strands of nineteen wires each, and were in use at some period from 1875–1880.

The first cost of the ropes is calculated from Roebling's price list for October, 1880.

The cost per ton per hundred feet of lift is seen to vary between .029 and .161 cents, but the latter figure is doubtless exceptional,—the rope was either of inferior quality, was removed some time before it was worn out, or was run over small sheaves or knuckle pulleys.

The averages and totals may be considered as a close approximation to the actual cost and average tonnage.

In the second table the cost at shafts per lift of one hundred feet is shown to be .053 cents, equivalent to .38 cents per ton of material raised to the surface,—a most remarkable agreement with Taylor's figures (.36) above cited.

Slope.	No. of Ropes.	Diam.	Length	Cost.	Tons.	Total Tons.	Cost Per Ton.	Cost Per 100 Feet Lift.
1	6	1¾″	900′	$3,240	66,616	375,700	0.86	0.095
2	2	2″	1000′	1,520	98,280	196,560	0.77	0.077
3	1	1¾″	850′	510	203,700	203,700	0.25	0.029
4	2	1⅝″	1000′	1,200	37,175	74,350	1.61	0.161
5	1	1½″	1200′	540	37,500	37,500	1.47	0.122
6	1	1¾″	1100′	660	77,700	77,700	0.85	0.077
7	2	1⅜″	950′	760	41,825	83,650	0.90	0.094
8	1	1½″	950′	428	70,950	70,950	0 60	0.063
9	1	1½″	675′	304	102,200	102,200	0.29	0.043
10	4	1¾″	820′	2.952	149,037	596 150	0.50	0.061
11	2	2″	1050′	1,596	166,650	333,300	0.48	0.046
Averages and Totals, 23			933′	$13,710	93,555	2,151,760	0.64	0.069
Shafts.								
1	2	1¾″	925′	$1,100	88,715	177,450	0.63	0.068
2	2	1½″	635′	762	117,180	244,360	0.32	0.051
3	2	1¼″	500′	350	86,222	172,445	0.20	0.041
Averages and Totals, 6			687′	$2,222	97,376	584,255	0.38	0.053

Comparing the cost in shafts and slopes we find they apparently stand as .053 to .069 cents per 100 feet of lift,—but it must be remembered that the slope lifts are *slope measurements*, not vertical lifts, the actual cost per 100 feet of *vertical lift* will therefore be much greater than .069 cts. If the slope angles average thirty degrees, this figure becomes .060×2=.138 cents per ton for each hundred feet of *vertical* lift that will cost but .053 cents at a shaft colliery.

In these tables the cost has been estimated by the *actual tonnage* (exclusive of the weight of the mine cars) raised. The *coal* raised does not exceed two-thirds of this amount, but the value of the discarded rope, estimated at one-third its cost has been considered an equal offset, and the figures given may, therefore, be taken as the average cost *per ton of merchantable coal.*

Assuming the above average figures of cost per ton at slope and shaft collieries to represent the *ratio of wear*,—i.e. 138:53,—we have a means of approximately determining the relative amount of wear due to sheaves and drums and to knuckle and bearing pulleys. Assuming an equal wear per ton per vertical lift of one hundred feet at both shaft and slope collieries, we have at slope collieries (135–53)=85:53 as the ratio between the wear on the slope and that on the drum and sheaves, being 61 and 39 *per cent.* respectively.

The wear on bearing pulleys in a slope is a true rolling friction (when the pulleys are in good order) and can be lessened only by proper attention to the condition of the pulleys and a free use of lubricants; but the wear occasioned by knuckle and deflection pulleys partakes of the character of the wear on sheaves.

But it is the 39 *per cent.* at slope collieries and the 100 *per cent.* of wear at shaft collieries that I propose to discuss. A small part of this wear is due to friction on the drum and sheaves, but the principal cause is the friction caused by the rubbing and grinding of the wires of each strand upon those in contact with it, and of the wires of each strand upon each other, whenever the rope is forcibly flexed or bent and simultaneously subjected to great tensional strain.

When an elastic bar of metal is bent, the under (concave) fibres suffer a strain of compression and the upper fibres one of extension, but as in a wire rope the strands cross diagonally from top to bottom, each strand bears its share of the weight by adjusting itself to the new condition by *slightly moving* upon those in contact with it.*

* It can readily be seen that if the strands were simply bound together and not twisted in a helix, the upper strands would sustain all the weight, the lower ones in contact with the sheave being subjected to a strain of compression.

This internal wear is greatly increased by the sand and dirt which inevitably finds its way into the body of the rope.

Other things being equal we may consider this wear on the sheaves and drum *inversely proportional to their diameters*, for the wear being as the friction, the friction is

1. Proportional to the *amount of movement* between the strands and wires when the rope *adjusts itself to a curved surface* or *readjusts itself to a straight line.*

2. This movement depends *directly* upon the degree of curvature which is inversely proportional to the diameter of the drum or sheave.

Although mining engineers recognize these principles in determining the size of drums, they do not, as a rule, place as much importance upon the size of sheaves and pulleys over which the rope runs. When proposition 1 (above) is thoughtfully considered it will be seen that the wear occurs *at the moment the rope is flexed* in passing upon a drum, hence the same wear must also be occasioned by a sheave of equal diameter, *and mark*, as the rope almost immediately *readjusts itself to a straight line* (prop. 1, above) in passing off the sheave on its way to the drum, the wear caused by the sheave is *precisely double* that caused by the drum of equal size.

As regards frictional wear it is far better to decrease the diameter of the drum than that of the sheaves.

A rule in common use is as follows:

"For every quarter of an inch in the rope diameter allow one foot in the diameter of the drum." The Roebling's Sons' Company give minimum drum and sheave diameters slightly smaller, and the Hazard Company figures nearly corresponding to those given by this rule. No smaller diameters should *ever* be used, and larger sized drums and sheaves will give much more satisfactory results.

I approach the subject of knuckle and deflection pulleys with much hesitation. The wear caused by a knuckle or deflection pulley used to effect a slight change in the direction of the rope, is influenced by precisely the same conditions that affect the wear on sheaves,—provided always, that the angle of deflection is sufficient to cause the rope to *conform to the curvature of the pul-*

ley for an appreciable distance along its contact surface. This will vary with the size and stiffness of the rope and the working load.

After much fruitless labor I am convinced that it is not possible to express by a formula the exact diameters of deflection pulleys that shall cause no greater rate of wear than the minimum drum and sheave diameters, but it seems patent that in any case where the deflection approaches 15° or 20° the knuckle or deflection pulley becomes to all intents and purposes a sheave and should be treated as such. For deflections ranging from 5° to 15° it might be well to use pulleys of size proportional to the deflection,—the diameter for 15° or 20° being equal to the minimum sheave diameter for rope of equal thickness.

XVI.

THE CONSTRUCTION OF IRON RAILROAD BRIDGES SUBJECTED TO CONCENTRATED LOADS UNDER HIGH SPEED.

By Charles W. Buchholz, Member of the Club.

Read April 16th, 1881.

My idea of venturing before you to read a paper on the "Construction of Iron R. R. Bridges Subjected to Concentrated Loads Under High Speed," is chiefly for the purpose of eliciting discussion on the subject and to draw more attention to it, and not at all to advance any dogmatic views, or to advocate any empiric standard of construction. What little I have to say will principally be confined to bridges of short spans: say below 150 ft. in length. Bridges of larger spans, and especially those that on account of their magnitude and use command universal attention, are generally talked and written about enough, before and after they are built; they are looked after and watched with great care; speed is reduced when trains run over them, and the slightest defect is at once remedied. The smaller structures re-

ceive no such generous treatment, although they require as much attention and thought, and often give more trouble to the designer and more frequently bring sorrow to the builder. There are, perhaps, but few railroad engineers deeply interested about this matter, because there are but few railroads to-day whose enormous traffic is of such a nature as to cause anxiety to their engineer in charge of the maintenance of way about the stability of the iron bridges on his road. Such bridges having, generally, been constructed by very competent men, by experts, whose share in the responsibility of their perfect safety is always assumed, and whose reputation is of as much importance, and certainly of more financial value than that of the average engineer in charge of railroad maintenance. The bridge builder labors, however, under great disadvantage. He is naturally desirous of getting all the work he can, and he has to compete against rivals, not only against his peers in the profession, but also against charlatans and humbugs. Specifications are generally furnished to him, and he has nothing to do with laying down the very basis of a sound and permanent structure, that is, the fixing of the live load per foot of track, unless he ventures to suggest from his own better knowledge, at the risk of losing his contract for so doing. The bridge builder very rarely has an opportunity to watch his handy-work after he has been paid his final estimate, and has, therefore, little practical experience how his bridge acts or works under the different effects of heavy loads, high speed and change of temperature; unless, indeed, one of his structures should cause a disaster, in which case the builder, be he ever so innocent as to the cause, will likely hear all about it. For these reasons I believe it to be an imperative duty of every important railroad company to have in its employ a competent engineer, familiar with the construction of bridges in all its detail, and familiar from experience on his own road with the behavior of bridges in doing their work. Such a man should then design all the bridges the railroad may need; could invite bids from honest builders for their construction, and should then bear the entire responsibility; for in such important matters responsibility ought never to be divided. If such engineers could not be had (and I admit that on account of the small pay generally

given to professional men on railroads, the best talent is engaged in private business) it would be much better for railroad companies to employ some bridge builder of reputation, whose known integrity is a guarantee for good work, and leave the whole matter of bridge construction with all its responsibility in his own hands. Above all things the work of designing should not be divided. The fixing of the number and size of the spans, the position of the roadway, whether on top, bottom or in the middle, the nature of the truss, the floor beams, and especially the assumed live load, are matters of the utmost importance, and a fixed rigid responsibility in those matters will alone insure that care and thought necessary to complete success. The progress of our railroads within these last ten years, as everybody knows, has been astonishing. Many of the more important railroads have more than doubled their traffic, the size and weight of their cars and locomotives has increased correspondingly, and several competing lines have increased the speed of their passenger trains until one begins to think that a limit of safety has been reached.

The first locomotive built in this country by Mr. Baldwin, the old Ironsides, weighing altogether in working order only a little over three tons, is now represented by engines weighing 50 tons, with over 3200 lbs. upon one pair of wheels, and capable of drawing four heavy passenger cars at the rate of 60 miles per hour. Not many years ago passenger trains rarely ran more than 30 miles per hour, and speed was always reduced when approaching bridges, even of short spans. Now, competition has fixed schedules that make it impossible to reduce speed for any structure, and it is the duty of the engineer to provide a roadway capable to stand this extraordinary wear and tear with perfect safety. Remember that 60 miles an hour is 88 ft. per second, and you will at once appreciate the great necessity of using all possible care and knowledge in assuming the live load per ft. upon which the bridges of such a railroad must be designed and proportioned. I am aware that the best bridge builders are alive to this fact, yet I am convinced that there are others, if they are aware of it, ignore it. Very few of the roadbeds of the most important railroads have increased in strength cor-

respondingly with the increase of the weight of their motive power; this is especially the case with their bridges of short spans, and the floor systems of all their bridges, although the best managed roads have several years ago removed all their earlier iron structures. Yet in spite of this experience there are bridges built on new railroads to-day hardly equal in strength to those removed by the old roads. I have recently seen in New York State, short span iron bridges put in, that I am confident will not outlast a wooden stringer, and are not half as safe. Upon the P. & R. R. R. they have removed all the old iron bridges built 30 or 40 years ago. They had great numbers of them, and I presume they were models of their time. They were certainly built by gentlemen of thorough technical training and experience, yet they failed because not sufficient allowance had been made for wear and tear, nor was the future increase in the weight of rolling stock sufficiently discounted. When I say these bridges failed I do not mean that they absolutely sunk down under a passing train, far from it. The very gentlemen who designed and built them, had grown with the times, saw the defects of their work and promptly remedied it. They saw that the new conditions imposed upon their bridges had destroyed their strength; they had done the duty for which they were designed, but the largely increased weight and the excess of wear and tear upon them—which nobody dared to anticipate—demanded a new method of construction and a less high estimate of the value of iron as to its permanence as a material for bridges. These same conditions exist still to-day, and the wise man will not flatter himself that he knows all about iron bridges and their infinite endurance, but will look to the past for instruction, and with due caution to the future. The question and the subject I would like to draw attention to, is not how to build an iron bridge for to-day that will bear with safety a given load per foot, but how to build a bridge that will do its work with perfect ease, without fear and trembling under any circumstances likely to occur on a large railroad, and do it for some time to come—not for ever, for I do not believe in the perfect permanency of any iron bridge, although some very prominent men in the profession have asserted and maintain, that an iron bridge is more durable than one built of stone.

With some reluctance, but with very firm convictions I approach the subject of what sort of a bridge would make a perfectly safe, and steady, and durable structure. I am sure that our boasted trussed system with links and pin connections will not do it; and, of course, I reject the use of cast iron angle blocks altogether. August Ritter, one of the most practical and able writers on the construction of bridges and roofs says: that a correct theory will always correspond with a sound practice, and in support of his assertion adopts his theory of calculating strains upon our American system of building. He asserts, and I thoroughly believe in him, that the strains upon the different members of any truss cannot be absolutely determined, unless all the members are hinged at their connections by pins or free moving sockets, and that it should be the constant endeavor of all designers to arrange their plans in conformity to this assertion, so that none but longitudinal strains can take place in any part of a main truss. This is unquestionably sound doctrine, and in all structures sustaining a uniform load, or in very large bridges where the live load is small in comparison to the dead weight of the bridge itself, these conditions can and should be adhered to. But when we come to smaller bridges, where the live load is as heavy or heavier than the structure itself, the theory does not correspond with experienced practice, and a more rigid system becomes absolutely necessary. To explain the effect of an engine weighing 50 tons, running suddenly upon a light bridge and rolling over it at the rate of 88 ft. per second, to arrive by figures and formula at a result that will express exactly in so many pounds the true weight exerted upon the bridge by this momentum and the actual weight, seems to me impossible, at least I am not aware that anybody has attempted to solve it, and it certainly is beyond my powers; I can only say that I have often seen and felt the effect produced. An ordinary truss bridge with pin connections cannot and does not for any length of time successfully resist this sudden and severe action. The enormous strains upon such a truss cannot be transferred quick enough from one abutment to the other; each panel must, as it were, sustain itself without any aid from the adjoining ones, and the result is a deflection immediately under the engine more abrupt

than if the whole bridge acted as a solid beam. The different members naturally move about their pin connection when the panel deflects, and every passing train increases by wear and tear this movement, until the whole truss, if not too weak, becomes too shaky and requires renewal. Excessive strength, close attention to the details, and absolutely true workmanship will partly overcome this want of rigidity in all truss bridges with pin connections, but can never make it as stiff and durable as a solid riveted girder.

A solid or a closely latticed girder will act as a solid beam and if care is taken and close attention is paid to the riveting, the wear and tear upon such a girder should be very little. Of course I know that the great objection to those structures is their cost when they exceed 50 ft. in length, and require field work in their erection. I know full well the great advantages of trusses with parallel chords and pin connections, where every part is finished in the shops, and nothing remains to be done in the field but putting the parts together. Yet I believe the difference in cost is much exaggerated, because a riveted bridge of any kind, although more work is required at the place where it is to be erected, the shop work is at the same time largely reduced, and with the new improvements of portable drills and forges the difficulty is not as formidable as it looks. Besides, cost ought not to be considered where it occurs as an offset to safety, but if cost is of vital importance it would be much better to reject iron entirely, and build a good wooden structure.

Recent practice has convinced me that I am right; a solid plate girder, over 80 ft. long, was lately built at one of our best bridge works, and I am inclined to think that they can be increased with safety and economy to a hundred feet long. Beyond that, however, economy would demand another system, and I venture to suggest, and am ready to defend an arched truss, a favorite design of mine. The arch like the plate girder has the advantage of transferring at once any sudden and heavy load to both abutments, and if the right form is adopted no great strains are produced upon any of its vertical members. All the sections of an arched truss are uniform and the strains upon any member can be determined with great accuracy and little labor. One of

the greatest advantages of an arched truss is that, while the arch itself should be solid and continuous, the vertical and horizontal members may be made in links, and put together by pins, without producing that panel deflection so injurious to trusses with parallel chords. The objection generally urged against the arched truss is its lateral weakness, the impossibility of lateral bracing between the top chord, yet this objection, it seems to me, is not well considered. Europe, and especially the continent, is full of these bridges, and nothing would induce the engineer's to change their practice. There is, of course, no difficulty at all of thoroughly bracing such a bridge, when the roadway is on the top, and if the floor system is well designed, there should be none when the roadbed rests upon the bottom. If the main trusses are placed a little further apart than is absolutely necessary, and the cross floor beams are firmly riveted directly to the vertical members, lateral braces can be introduced that will prevent all side motion. I am sure, such a bridge would not cost much more than a truss with parallel chords, and if it did, our wealthy railroad companies would not object to it, provided they would be assured of getting a more permanent and safer structure. In conclusion, I beg leave to point out the great necessity of extraordinary care in designing the details of any kind of bridge, the excess of strength imperatively needed in the whole floor system, since the sudden and rapid increase of concentrated loads upon one pair of drivers on modern locomotives. There are to-day but few railroad engineers aware of this change in the strains upon the floors of their bridges, and it seems to me very proper to draw attention to it, as very frequently the best designed bridges in their main trusses, become very troublesome when the floor is weak.

XVII.

THE SEWERAGE OF MEMPHIS, TENN., AFTER A TRIAL OF ONE YEAR.

By WM. HENRY BALDWIN, Member of Club.

Read April 16th, 1881.

The sewerage system of Memphis has now been in operation a little more than one year. The principal lines from the easterly and westerly portions of the city were brought together in the latter part of July, 1880, and the sewers were then ready for public use, although many houses had already been connected.

As this is the first instance where the system here adopted has been applied upon anything like so extensive a scale, it has very naturally attracted considerable attention and persons interested in such matters have been desirous to know what are its distinctive features and wherein it differs from the ordinary practice, but more especially to find out its practical operation when brought down to everyday use—in fact to know how it actually works.

Much has already been written on the details and methods employed in constructing the sewers of Memphis. Engineers and others have commented upon and criticised the general features of the system, and have discussed the claims made by its author to originality in its application to towns and cities. We will not attempt to say anything about originality of design, for its author is well known to be fully able to speak for himself on this subject. Nor do we propose to advocate or defend the peculiar system of sewerage adopted in Memphis, but only to bring together such information as is available from observations made thus far, which may help the reader to form an opinion of his own. We will proceed then, in the first place, to consider some local topographical and other features having a controlling influence in the application of any system of sewerage to the city of Memphis,—secondly, to review some of the distinctive features and characteristics of the system of sewerage adopted for that city, but having a general application independent of any local conditions and which constitute a marked and important differ-

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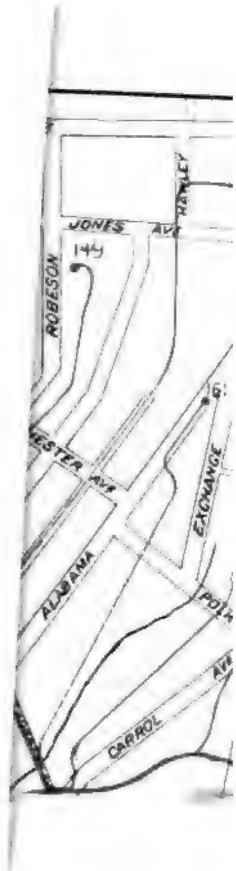

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conditions and which constitute a marked and important diff

ence between this and any other method of sewerage heretofore used in the public works of cities, and, finally, to note some observations made during the past year, showing the disposal of domestic and household waste by water-carriage; the amount and nature of the deposit in the pipes and the method successfully adopted for its removal; the quantity of water discharged through the sewers at different hours throughout the day and night; the velocity of flow of water through the pipes and the consequent length of time required for matters introduced into the sewers to find their way out and be discharged into the river; and any other items of interest having a tendency to show the practical operation of the sewers during the first year of their service, and their condition at the present time.

The writer is indebted to the courtesy of Major J. H. Humphreys, Engineer in Charge of the works, for notes and information very cheerfully furnished for this paper.

When the writer arrived in Memphis, only a few weeks after the abatement of the fever which raged so fearfully during the summer of 1879, it was thought essential to secure a residence, light, airy and with plenty of sunshine, and, at the same time, it seemed desirable to find a place overlooking the river where one could enjoy the beautiful scenery which northern people expect on the banks of a great river. But Memphis, although built on a bluff, does not overlook the river. One or two principal streets, at an elevation of forty or fifty feet above the water, are occupied by warehouses, and are used for commercial and other business purposes, while the rest of the city slopes rapidly away towards the interior.

Drainage is therefore *from* the Mississippi River and not towards it. About half a mile back from the bluff a small stream winds along through an alluvial bottom, into which it has cut its way to the underlying stratum of sand and gravel, leaving perpendicular banks from twelve to fifteen feet high on each side. The principal streets are bridged across this stream and rise again quite rapidly to the suburban and rural portion of the city beyond. The flow of this stream, called the Bayou Gayoso, is in a northerly direction, its banks become gradually lower and the alluvial bed through which it flows spreads out to a greater

width, until finally it discharges into the Wolf River, about half a mile above the junction of that stream with the Mississippi. Although the above description is somewhat voluminous the stream itself is quite insignificant at most times, but, as it lies wholly within the city, having the business and thickly populated part on one side, with the suburban and rural on the other, it will be seen that, though small, it plays an important part in the sanitary condition of the city.

The Mississippi River, once or twice every year, and sometimes oftener, rises to a height of from fifteen to twenty feet above its ordinary level and, at such times, its waters back up into the small stream just described, overflowing its banks for a length of more than a mile within the city, submerging the low grounds in its vicinity and keeping them under water for weeks at a time. This stream serves a very good purpose in carrying off the rain water from the streets and gutters, but it is evident that, if all the waste and sewage of the city were allowed to flow into it, the districts submerged would, on the subsidence of the water, be covered with slime and filth and, when exposed to the hot sun of that climate, would seriously impair the sanitary condition of the city.

In designing any system of sewerage there was then no alternative but to provide collective sewers, one on each side of the bayou, to receive the flow as it comes down the streets and alleys and to convey it away to a point whence it will not return. It was necessary to have these collective sewers as near as possible to the bayou, both to avoid deep cuttings and to have as narrow a space as possible between the two lines.

There are no streets or alleys running in a direction at all suitable for the purpose, as Memphis is laid out on the rectangular plan, hence it was necessary to lay the collective sewers through private property for almost their entire length, in fact considerably more than two miles. An undertaking of that kind required great boldness on the part of those who designed it, and could not have been accomplished without extraordinary powers granted by the State. But the citizens of Memphis were fully in sympathy with the enterprise and willing to do almost anything to escape the terrors of an epidemic, so that almost invariably the right of way was conceded without opposition or cost.

A point of discharge having been selected, it was ascertained that a uniform fall of one in six hundred could be secured for the main sewers. An important condition of the system may be mentioned in the outset, namely that no angles or sharp turns should be made in any of the sewers, especially in the mains. In view of the fact that a sewer through private property could not be easily retraced when once buried out of sight unless carefully located, and also to have the lines as nearly straight as possible, the mains were laid out in curves and tangents with the same care as a railroad, points being fixed at intervals of twelve and one half feet to secure accuracy of alignment, and the radius of curvature was made as great as possible, seldom less than one hundred feet on the westerly side of the bayou, while on the easterly side, where obstructions were not so serious, a uniform radius of three hundred feet was selected and secured with but few exceptions.

As the duty of locating these lines through private property devolved upon the writer, he may be unduly impressed with some of the details of this part of the work, and still retains clearly in mind the strife to get a line through cotton sheds and back yards, among shanties and high brick walls, and beneath dwellings, without cutting away the brick columns on which most of the houses are built in that climate, and at the same time to maintain a direct line with true curves. The most serious obstacle met with was the large underground cisterns used to secure the domestic supply of rain water. The people of the South thoroughly understand and appreciate the art of preserving rain water for drinking purposes, and when a cistern proves to be a good one, the owner is unwilling to give it up, as the water of a new cistern is sure to be bad for a year or more, and, from some unaccountable reason or others, is very likely to be worthless altogether. The value of good rain water cisterns is still further enhanced when compared with the muddy water pumped directly from the river for the city supply. One may then very well imagine the disappointment and disgust felt by a party of engineers upon discovering one of these great cisterns directly in the way of a line carefully spied out after days of labor. But, like all things in engineering, the exercise of pa-

tience and perseverance carried the work along to its completion.

Without trespassing further upon your patience with details of a preliminary nature, we may say that the main lines have been constructed on each side of the bayou according to the design sketched above. For local reasons they were brought together and united in a brick sewer, about half a mile from the outlet. One of the lines is carried over the bayou to effect this junction, and is supported on a wrought iron bridge made for the purpose, resting on brick piers and having a clear span of 61 feet 8 inches. The sewer itself over the bridge and its approaches is of cast iron with lead gaskets. The approaches to the bridge on each side consist simply of the pipe, supported by brick piers, one under each joint. As soon as the approaches come near enough to the ground and far enough from the stream to be covered with a mound of earth, the sewer is built of ordinary vitrified clay pipe, supported on small arches resting on brick columns, the pipe being protected from accident and the action of the weather by a row-lock of brick turned over it, four (4) inches thick. This method of construction upon brick arches was frequently resorted to in crossing ravines or in low ground too unstable to sustain the sewers without artificial support. They were of uniform design, having arches of eight (8) feet span and one (1) foot rise, resting on columns of brick, extending down to a good foundation.

From the above description it will be seen that the Memphis system of sewerage consists,

FIRST, of main lines laid with a uniform fall (two inches in one hundred feet) and in practically straight lines.

SECOND, of branches discharging into the mains at each of the streets or alleys crossed until the mains themselves are gradually reduced in size, as the supply of water diminishes, and they in turn become branches. The sewerage of Memphis is then divided into many small areas, each of which may be properly regarded as a small drainage system of its own independent of all the others.

The sewers of Memphis are designed to remove as quickly and completely as possible all the liquid wastes of the house-

hold and the discharge from water-closets. The amount of water furnished by a city supply affords a basis for estimating the amount to be carried off by its sewers, provided all the city is furnished with sewers, and also that no storm water be admitted. To be sure, much water is supplied from wells and cisterns, especially in a southern city, but this is doubtless more than offset by water used in garden-hose, street-sprinkling and in other ways, where it does not find its way to the sewers. Knowing then approximately the amount of water supplied, the sewer pipes may be so proportioned as to be nearly filled each day and thus kept thoroughly washed out. But it is essential that no storm water be admitted, not even that which falls upon the roofs; for the amount of rain falling on the roof of a dwelling in course of a few hours is so entirely disproportionate to the amount of water actually used by the occupants of the house during the same time, that a system of drains designed to convey only the domestic water supply would be entirely inadequate to carry off the rain water even from the roof, while on the other hand a system of pipes large enough to carry off the rush of water from an occasional storm would be many times too large to conduct the domestic supply during all the fair weather in the year. It may seem superfluous to emphasize this feature of the Memphis system of sewerage further than to say that the entire and not the partial exclusion of storm water is one of the essential and vital conditions upon which its success depends, for the reason, among many others, that this is the only possible way in which a uniform daily flow of water can be secured sufficient to flush out the pipes and keep them clean.

Pipe sewers from ten to eighteen inches in diameter have been used for many years in some of our principal cities. More than fifty miles are now in successful operation in New York. These pipe sewers carry a fair weather flow seldom exceeding five or eight per cent. of their capacity, a pipe eighteen inches in diameter usually having not more than half an inch to perhaps two inches of water in it. Dependance has to be placed on the occasional action of storms to wash out any deposit left by this small daily flow, but when storms are long delayed, these deposits lie in the pipes and fester and decay for days and weeks, often be-

coming caked so hard and solid as to resist the action of the storm when it does come.

If there could be a storm every day or, in other words, if the pipes could be filled full of water every day, the agent on which we now depend for occasional relief would then be in constant operation. This is precisely the condition of the Memphis sewers; the flow at night is small, but in the middle of the day it amounts to a storm in pipes properly proportioned.

It seems reasonable to expect that, whenever a pipe can be supplied with water enough daily to fill it half full, it will be kept clear without artificial means. Certainly it seems more likely than if filled only at the infrequent and irregular occurrence of storms which may be delayed for weeks or months.

In estimating the size of the pipes to be used for the Memphis sewers it was designed that the pipe should be filled half full by the ordinary midday flow, leaving the other half for contingencies and for future increased demands. This ratio was maintained by reducing the size of the pipes, toward the head of the system, in proportion to the diminished quantity of water to be carried off. But there is a practical limit beyond which the size of the pipes cannot be reduced. Assuming the house drains to be four inches in diameter and providing for an enlargement at their junction with the public sewer, we are limited to a diameter of six inches as the smallest practical size for the public sewer. The usual rates of fall in Memphis are from six to twelve inches per hundred feet, sometimes more. The amount of water which a six inch pipe will carry away at these rates of fall is known to be from four to six thousand gallons per hour, and the velocity of flow from one hundred to one hundred and fifty feet per minute. It would require a great many dwellings to furnish so large a supply of water as that. By reference to the gaugings of the flow of water in the Memphis sewers, given on another page, it will be seen that the greatest discharge of water in any one hour is only about twenty per cent. more than the average throughout the twenty-four hours of the day. At this rate, to secure a supply of 5000 gallons in one hour would require an average of 4167 gallons per hour, or a total of one hundred thousand gallons per day, as much water

as would be likely to be furnished by two hundred ordinary house drains.

It is a new departure in engineering to assert that a six inch pipe laid on an inclination of one in one hundred and fifty is large enough to drain two hundred dwellings, but the above line of reasoning appears to indicate as much, and the experience of the past year in Memphis proves the efficiency of small pipes far more conclusively than any mere pen and ink logic could do.

But, unless the supply of water is great enough to fill the pipes at least half full every day, it is well known that they will become gradually filled with sediment, and will require some artificial means of keeping them clear. The most effective artificial means known which can be automatically applied is to discharge at intervals a quantity of water large enough to rush through the pipe and clear its way. Five thousand gallons per hour is only eighty-three gallons per minute, and it is not necessary to maintain the flow for a very great length of time.

The Field flush-tank used in Memphis discharges 112 gallons of water in a little less than a minute directly into the head of each of the six inch pipes, and the rush of this water has been distinctly observed for a distance of 1400 feet or more, according to the rate of descent of the sewer.

It remains for experience to prove if this quantity of water is large enough to effectually wash out the pipes when discharged once or twice a day. The quantity of water required to supply the flush-tanks of the city is almost inappreciable for, while the sewers discharge about two million gallons daily, the amount of water furnished by the flush-tanks would be but 30,000 gallons if all were emptied twice a day.

It remains also for experience to show if the tanks will work when let alone or when subjected to only a reasonable amount of attention. In this particular we have the experience of a little more than one year, and the officers in charge of the sewerage department of Memphis assert that their operation has been successful.

Very few tanks have caused any trouble, and these usually from defects in the castings or in setting them. Such defects were soon discovered and remedied. It would be very bold to

assert that the flush-tanks used in Memphis are not susceptible of improvement. Some improvements have already been made and doubtless others will be from time to time, but the principle on which they operate appears to be established and their success dèmonstrated. Nor is it likely that the size of the tanks has been correctly determined in every instance, but as a flush-tank costs no more than an ordinary inlet-basin or man-hole, and as only one is required for each line of sewer, their re-construction would be but a trifling matter if a different size should be found necessary.

Before leaving the subject of flush-tanks it may be well to allude to the mistaken impression in the minds of some that the whole system of sewers require to be flushed, or that there is any concert of action of the tanks with each other, or that their discharge need be regulated in any way to conform to each other.

A moment's reflection will show that, as they are situated only at the dead ends of the sewers they are necessarily widely apart; each one operates only upon the sewer immediately below it and hence is entirely independent of all the others.

There is nothing above it to be obstructed if it gets out of order, hence it can be taken up and repaired or replaced if need be without any interference with the rest of the system, and finally no part of the sewers needs flushing except the dead ends of the small pipes.

So much has already been written about the details of the construction of the Memphis sewers, the manner of laying the pipes and making house connections, and many other matters interesting, but now grown familiar, that allusion will only be made incidentally to these things; but there are two considerations of importance which will be briefly noted. FIRST, the ventilation of the sewers, and SECOND, the flow of water in them. Both these subjects have now been tested sufficiently to furnish information of interest and value. The first of these subjects involves the question of sewer gas. The other may enable us to ascertain how long a time sewage remains in the pipes before it is discharged into the river. The two considerations when taken together will enable us to estimate the possibility of the decomposition and decay of sewage while it remains beneath the streets of the city.

We have already considered the general plan of the sewerage system, and have seen that it consists first of a brick sewer twenty (20) inches in diameter and about 4,000 ft. long, receiving the discharge of two pipe lines, one of fifteen (15) inches diameter, and the other twelve (12) inches.

Memphis is laid out on the rectangular system of streets and alleys. Sewers are laid in the alleys, and usually descend in direct lines and discharge into the mains within a distance of half a mile or less of their source. The whole system then may be said to consist of numerous branches, each of which is independent of all the others, is usually not more than half or three-quarters of a mile in length and may properly be regarded as a small system of its own.

A description of the ventilation of one of these branches will apply equally well to any other, and hence to the whole sewerage system.

The ventilation is perfectly simple and equally effective. FIRST, a fresh air inlet is placed in each branch near its junction with the main sewer. SECOND, every house drain is required by law to be, and in fact is, left open without any main trap, and is extended up through the several floors of the house, by means of an iron soil pipe four inches in diameter, passing through the roof and opening into the open air above. By this means a free circulation of air is secured at all times and no back pressure or accumulation of foul gases or vapors is possible. There is not much movement of air through the sewers, but where any draught has been observed it has been from the street inward to the sewer, as proved by the fact that a burning piece of paper is drawn into and not blown out of the fresh air inlets. Every house drain is a ventilator almost as large as the sewer itself, and, as they all extend above the roofs of the houses, some terminate at a much greater elevation above the ground than others, hence the circulation of air is doubtless upward in some and downward in others. It is perhaps a matter of regret that more extended observations have not been made on this subject, but, on the other hand, the fact that nobody has been led to investigate the subject goes far to prove that the operation of the ventilation system is entirely satisfactory. In fact, the great number of ventilators

afforded and their size, as compared to that of the sewer, render the accumulation and stagnation of foul air impossible.

As to the flow of water some observations have been made by passing floats through the sewers and noting the time required for them to go from one man-hole to another. By this means the velocity in the mains has been ascertained to be about two and one-half feet per second. These have a grade of only two inches per hundred feet, but the branches are much steeper, having a fall usually about six inches in one hundred feet, hence we may conclude that the flow of water in them is more rapid than in the mains. From all available information we may safely estimate the average velocity throughout the city to be not less than two feet per second. On this subject the engineer in charge of the work, Major J. H. Humphreys, in a recent letter says, that he should consider an estimate of two feet per second throughout the entire city a very safe estimate as, in his opinion, the flow in most places would be considerably greater. The main sewers are only about two miles in length. Assuming a velocity of two feet per second or one mile in three-quarters of an hour, water would traverse their entire length in an hour and a half. The branches are usually about one-half to three-quarters of a mile in length, and at the same velocity water would run through the longest in half an hour. Few, if any houses, connected with the Memphis sewers are more than two and a half miles distant from the outlet, while the vast majority are within considerably less than two miles, hence we may safely conclude that anything finding its way into any of the sewers would be discharged into the river within two hours or three at the most. This evidently allows but little time for sewage to become foul or offensive, especially as it is kept in constant motion and is exposed to fresh air all along the line, by the complete system of ventilation described above. This rapid flow not only renders the stagnation and putrefaction of water impossible during the short time it is allowed to remain in the sewers, but also prevents the collection of deposits of solid matter to any considerable extent, especially the gradual silting in of fine matter, but occasionally foreign matter will find its way into a sewer, such as rags, bunches of cotton, pieces of brick or stone, etc., not readily

carried along by the current and likely if neglected to form an obstruction. For the detection and removal of such things resort has been made to the now familiar device of passing hollow metallic balls through the pipes of a size only a little smaller than the pipes themselves. A single instance of the practical advantage of the device appears in the experiment on the twenty (20) inch brick sewer, where a ball fifteen (15) inches in diameter went through without difficulty, but one having a diameter of seventeen (17) inches was stopped by a mass of cement carelessly left in the sewer when it was built, and was thus detected. The engineer in charge of the works, Major J. H. Humphreys, in a recent letter says, that nothing more substantial has been found than rags and a sort of gelatinous deposit, which seems a fine silt bonded by what seems pulp, formed by the dissolution of paper. This is easily purged out by the use of the balls described above.

No pipes have ever been stopped by the gradual silting in of solid matter. There have been a few instances of stoppage in six-inch pipes; these have almost invariably been caused by a bone or a splinter of wood, a little longer than the diameter of the pipe, getting crosswise and forming an obstruction. The entire number of such instances to July last was twenty-one (21), and the average cost of their removal was $15 each, or a total of $300 a year in thirty-two (32) miles of sewers.

During the past winter the weather in Memphis was exceptionally cold, and much water was allowed to run to waste to prevent freezing in the service pipes. This caused some inconvenience by turning so large a quantity of water into the main sewers. The twenty (20) inch brick sewer was equal to the emergency and has never been filled full, but some of the twelve (12) and fifteen (15) inch pipes were surcharged for several weeks. This led to a series of observations and experiments. The pipes were opened in various places throughout the city by uncovering the T branches left for that purpose, and were found to have a rapid, strong flow of water and apparently clear from deposits. The six-inch branch sewers were found in every instance fully equal to the extraordinary demand, as none of them were filled more than half to three-fourths full.

Observations made on the 20-inch brick sewer consisted in passing floats from one man-hole to another, to ascertain the velocity of flow, and also by taking gaugings of the depth of water at each hour during the day and night. Similar observations have also been taken at intervals since then. The rate of fall in this sewer where the notes were taken is one in four hundred and sixty.

The first experiment made to ascertain the velocity of flow was on Friday, Dec. 17th, 1880, at 3.30 P.M. Circular floats, four (4) inches in diameter and one (1) inch thick were observed to pass from Jackson St. to Centre Alley, a distance of 1733 feet, in eleven (11) minutes and twelve (12) seconds, indicating a surface velocity of 2.58 feet per second. Depth of water 13.75 inches.

On Dec. 20th, 1880, eleven similar floats through the same sewer between the same points, with the same depth of water, indicated an average velocity of floats of 2.53 feet per second. Subsequent experiments show a velocity somewhat greater, though the depth of water was considerably less, for instance four similar floats passed from the same point through a distance of 420 feet, at an average velocity of 2.65 feet per second, although the depth of water was only 12 inches. The floats at this time could not be followed through the lower portion of the sewer, as it was submerged by the back water from the Mississippi river for several weeks in succession. See Table II, page 284.

Observations to determine the rate of discharge of water during the day and night have been made by taking gaugings of the depth of water flowing through the 20 inch brick main at Jackson street, each hour of the twenty-four, the first beginning on Monday, December 20th, at 6 P.M. A tabular statement is given on page 286, Table IV, showing the gaugings taken at this time, and also another series taken on Saturday, April 30th, 1881. In order to facilitate the examination of data thus furnished, a calculation has been made of the probable velocity and discharge in a sewer, such as the one in question, with water flowing at various depths of from one to twenty inches (full). These calculations are made according to Kutter's formula, by the use of the diagrams prepared by Rudolph Hering, for the American Society of Civil Engineers, October 16th, 1878,

Table III. The probable velocities and discharges thus computed are also placed for convenience in Table IV.

No discussion of the data and information here furnished will be made now, further than to remark that the flow of water on December 20th, was probably disturbed somewhat by slight obstructions then existing in the sewer but subsequently discovered and removed.

The large flow of water during the night when compared to the average and maximum flow may possibly suggest the suspicion that the sewers are carrying a constant flow of subsoil drainage finding an entrance through imperfect joints in the pipes. There are a good many reasons for concluding that the sewers do not carry subsoil drainage. The entire quantity of water discharged is too small for that, being less than one half the quantity pumped by the Water Company; and again the large minimum flow was maintained during the dry season when no subsoil water flowed out through the drainage tiles laid in the same trenches beside the sewer pipes.

It is a matter of regret that the hourly pumpage by the Memphis Water Company cannot be furnished together with the gaugings of the sewer during the same time. The works being on the Holly system of direct supply, this could easily be done by a concert of action among the authorities. The Water Company during the cold season last winter supplied about four million gallons daily. They now claim to be pumping nearly five millions, but the flow through the sewers is apparently less than it was at that time.

The tabular statement of water supplied by the Holly system at Burlington, Iowa, for which we are indebted to the courtesy of Mr. Ira Holly, superintendent, and also the record of hourly supply of water in St. Louis, derived from official reports of that city are given on page 284, but perhaps the record of high service in the city of Boston gives the nearest approach to the Memphis water supply of anything available. Table I.

The writer is painfully aware of the fact that information thus far available is much too small to afford a basis for reliable conclusions. It is to be hoped that more extended observations will be made in the future, especially on the relation between the water supply and the sewer discharge.

The subject will be continued as soon as further information can be secured.

TABLE I.

Table showing the number of gallons of water supplied during each hour of the day and night in various cities.

Hour.	Burlington, Iowa. 1881.		St. Louis. 1880.			Boston, Mass. (Cochituate High Service.) 1879.	
	Apr. 25-26.	Apr. 26-27.	Jan. 17.	Jan. 17 & 18	Jan. 18.	Jan. 21 & 22	Apr. 17 & 18
6 P.M.						111,840	87,730
7 "	32,508	40,338		620,000	700,000	115,710	90,210
8 "	27,288	31,212		610,000	660,000	113,370	87,730
9 "	26,640	30,708		610,000	700,000	114,890	75,640
10 "	24,640	28,080		555,000	700,000	117,210	75,175
11 "	24,300	26,820		570,000	560,000	94,250	69,440
12 Midnight.	23,760	24,588	570,000	560,000		104,750	63,395
1 A.M.	23,868	24,012	610,000	560,000		100,580	59,365
2 "	25,344	24,948	730,000	795,000		114,290	58,280
3 "	25,092	22,824	700,000	795,000		103,720	57,660
4 "	25,056	23,472	790,000	820,000		90,640	57,660
5 "	25,092	23,400	825,000	765,000		100,370	58,125
6 "	26,820	24,840	850,000	970,000		119,810	66,650
7 "	28,224	27,648	790,000	1,025,000		142,250	87,265
8 "	37,836	27,656	880,000	1,025,000		141,420	100,905
9 "	47,844	41,418	835,000	1,170,000		124,330	105,550
10 "	47,898	55,836	950,000	1,115,000		146,840	107,260
11 "	49,680	44,010	1,000,000	1,115,000		137,230	102,920
12 Noon.	56,700	49,032	1,000,000	1,170,000		121,420	97,495
1 P.M.	34,290	32,886	1,600,000	1,230,000		124,400	96,565
2 "	50,328	42,822	875,000	1,210,000		116,730	95,325
3 "	51,462	44,874	815,000	1,210,000		113.530	95,480
4 "	54,810	46,926	690,000	830,000		114,920	95,325
5 "	56,430	46,764	635,000	775,000		107,090	89,280
6 "	56,322	41,850	615,000	735,000			
Totals.	882,252	836,964				2,791,590	1,980,435
Average per hour.	36,760	34,874				116,316	82,518

TABLE II.

Table showing observations to determine velocity of flow of water in brick sewer at Memphis, Tenn., by passing circular floats 4 inches diameter and 1 inch thick.

Diameter of sewer, 20 inches.

Rate of fall, 1 in 460.

Date.	Location.	Distance.	Depth of Water.	Velocity of Floats.	Remarks.
Dec. 17, 1880.	Jackson St. to Centre Alley.	1733 ft.	13.75 in.	2.58 ft. per second.	
Dec. 20, 1880.	" " "	1733 "	13.75 "	2.53 " "	Mean of 11 floats.
May 3, 1881.	Jackson to Overton St.	420 "	11.50 "	2 65 " "	Mean of 4 floats.
June 18, "	" " "	420 "	12.00 "	2.60 " "	
" "	Jackson St. to Centre Alley.	1733 "	11.50 "	2.82 " "	
July 15, "	Jackson to Overton St.	420 "	12.00 "	2.57 " "	
" "	Main to Front St.	500 "	12.00 "	2.82 " "	

TABLE III.

Table showing the probable velocity and discharge of water in a brick sewer of circular cross-section. Diameter, twenty (20) inches. Rate of fall, one in four hundred and sixty (1 in 460). Depth of water in the sewer, from one inch to twenty (20) inches.

Determined from Kutter's formula by the use of Hering's diagrams, assuming a coefficient of friction of .015.

Depth of Water in Sewer.	Portion of Perimeter of the Sewer covered with Water.	Sectional Area of Water flowing in Sewer.	Velocity of Flow per Second.	Discharge per Hour.	Remarks.
Inches.	Inches.	Square Inches.	Feet per Second.	Gallons per Hour.	
20.0	62.83	314.16	2.45	143,932	Sewer running full.
19.0	53.81	308.28	2.70	155,650	
18.0	49.96	297.81	2.77	154,262	
17.0	46.92	284.61	2.79	148,489	
16.0	44.28	269.43	2.81	141,016	
15.0	41.89	252.74	2.80	132,192	
14.5	40.75	243.95	2.78	126,819	
14.0	39.65	234.89	2.76	121,231	Velocity of float, 2.53.
13.5	38.57	225.63	2.73	115,186	
13.0	37.52	216.16	2.70	109,139	
12.5	36.47	206.56	2.67	103,133	
12.0	35.45	196 81	2.63	96,793	Velocity of floats, 2.57—2.60--2.82.
11.5	34.43	186.97	2.59	90,555	Velocity of floats, 2.65—2.82.
11.0	33.42	177.04	2.55	84,421	
10.5	32.42	167 03	2.51	78,421	
10.0	31.42	157.08	2.46	72,260	
9.5	30.42	147.08	2.40	66,009	
9.0	29.41	137.11	2.33	59,740	
8.5	28.40	127.19	2.25	53,515	
8.0	27.38	117.35	2.17	47,619	
7.5	26.36	107.60	2 09	42,053	
7.0	25.32	97.99	2.00	36,648	
6.0	23.18	79.27	1.81	26,830	
5.0	20.94	61.42	1.61	18,491	
4.0	18.54	44.73	1.40	11,710	
3.0	15.90	29.55	1.12	6,189	
2.0	12 87	16.35	0.81	2,476	
1.0	9.02	5.87	0.38	417	

TABLE IV.

Table showing gaugings taken at each hour during the day and night in the circular brick sewer at Jackson Street, Memphis, Tenn., with the corresponding velocity and discharge of water as determined from Kutter's formula by the use of Hering's diagrams.

Diameter of sewer, 20 inches (circular).

Rate of fall, 1 in 460.

Assumed coefficient of friction, .015.

December 19th and 20th, 1880.				June 17th and 18th, 1881.			
HOUR.	Measured Depth of Water.	Computed Velocity of Flow.	Computed Discharge during the Hour.	HOUR.	Measured Depth of Water.	Computed Velocity of Flow.	Computed Discharge during the Hour.
	INCHES.	FEET PER SECOND	GALLONS PER HOUR.		INCHES.	FEET PER SECOND.	GALLONS PER HOUR.
6 P.M.	14.5	2.78	126,819	6 P.M.	11.5	2.59	90,555
7 "	14.5	2.78	126,819	7 "	11.5	2.59	90,555
8 "	14.0	2.76	121,231	8 "	12.5	2.67	103,133
9 "	14.0	2.76	121,231	9 "	11.5	2.59	90 555
10 "	13.0	2.70	109,139	10 "	11.0	2.55	84,421
11 "	13.0	2.70	109,139	11 "	10.0	2.46	72,260
12 Midnight.	13.0	2.70	109,139	12 Midnight.	10.0	2.46	72,260
1 A.M.	12.5	2.67	103,133	1 A.M.	9.0	2.33	59,740
2 "	11.5	2.59	90,555	2 "	8.0	2.17	47,619
3 "	10.5	2.51	78,421	3 "	9.5	2.40	66,009
4 "	7.5	2.09	42,053	4 "	9.5	2.40	66,009
5 "	8.5	2.25	53,515	5 "	9.5	2.40	66,009
6 "	13.0	2.70	109,139	6 "	10.0	2.46	72,260
7 "	13.0	2.70	109,139	7 "	11.5	*b* 2.59	90,555
8 "	13.5	2.73	115,186	8 "	12.0	2.63	96,793
9 "	13.5	2.73	115,186	9 "	12.5	2.67	103,133
10 "	13.0	2.70	*114,902	10 "	12.5	2.67	103,133
11 "	*13.0	2.70	*117,925	11 "	12.5	2.67	103,133
12 Noon.	*13.5	2.73	*116,763	12 Noon.	12.5	2.67	103,133
1 P.M.	13.0	2.70	109,139	1 P.M.	12.5	2.67	103,133
2 "	14.0	2.76	121,231	2 "	12.0	2.63	96,793
3 "	13.5	2.73	115,186	3 "	12.0	2.63	96,793
4 "	12.5	*a* 2.67	103,133	4 "	12.0	2.63	96,793
5 "	13.0	2.70	109,139	5 "	12.0	2.63	96,793

Total Discharge.......................2,547,262

Average per Hour........ 106,136

Excess of Maximum Flow above the Average..........19.4 per cent.

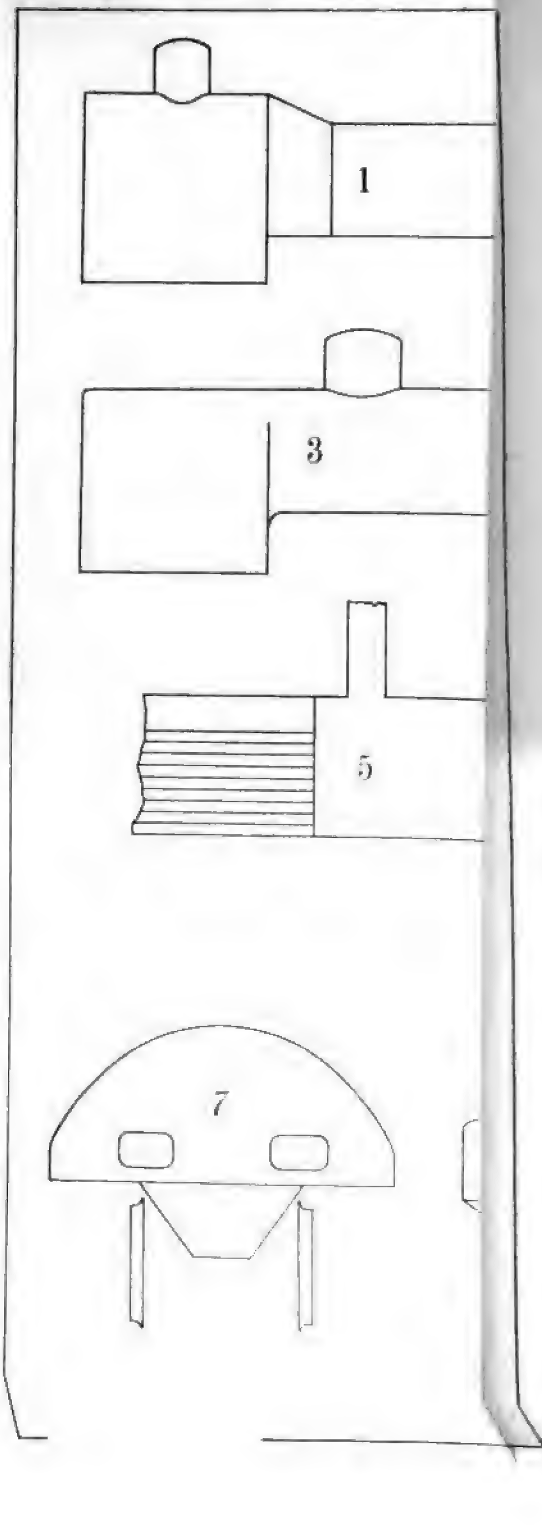
Total Discharge.......................2,072,570

Average per Hour 86,357

Excess of Maximum Flow above the Average......... 19.4 per cent.

*NOTE.—Depth of Water at 10.30 A.M.......................... 15 inches.
30 A.M..........................14 inches.
ocity of Floats................. ......2.53

b Velocity of Floats.............2.60 to 2.82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XVIII.

ON THE COMPARATIVE ANATOMY OF LOCOMOTIVE ENGINES.

BY GEORGE BURNHAM JR., Member of the Club.

Read May 21st, 1881.

IN some respects a machine bears a close resemblance to an animal, and, though this analogy is not at all one of form, but entirely of function, still it is not out of the way to speak of the anatomy of the machine, as well as of the animal. Nothing could be more unlike in appearance than a horse and a locomotive, and yet the latter is simply man's substitute for the former in its most important capacity of a beast of burden. Though so entirely dissimilar to the eye we are so conscious of the identity of function of the two that we constantly speak of the engine that draws us and our goods as the "iron horse," and I think we may carry the analogy further than the mere title, and compare the metallic bones and sinews of different types of engines, with the same profit that the naturalist derives from the comparative study of flesh and blood mechanisms. At the outset we must note one striking difference between the study of the machine and that of the animal. In the former case we can usually obtain inside or authoritative information, as well as outside knowledge, or that derived from our own or others observation; in the case of the animal, the outside knowledge only is obtainable. In other words, if the engineer wants to know why a particular lathe has exceptionally long shears, he can either watch the machine at work, or he can go to the maker and ask him why the tool was so constructed; and if he clothe his question in language sufficiently polite it is highly probable that he will get a satisfactory answer. If the naturalist, however, wishes to know why the horse travels on a solid hoof, while his relative the cow is furnished with a cloven foot, his only resource is the outside method, the study of the animals themselves in their relation to each other, and their environment; extending

his researches backward, if he pleases, to the dawn of animal history as recorded in the rocks.

The machine world is still in its infancy, and hence we have abundant data of both kinds, the *inside* and the *outside*, as its historians have stood in the double relation of observer and producer; yet, to carry our idea farther, we can imagine a time when an archæological class of machines will exist, all records of which have been lost or destroyed, and which will have to be studied with as little assistance as that granted to the paleontologist in his endeavors to unravel the mystery of the fossil.

Leaving this rather barren field of speculation, let us apply the method of observation to the locomotive engine, and see what may be learned therefrom. Fig. (1) is a sketch of the typical American locomotive boiler of to-day, and fig. (2) is the rear portion of one of the earliest engines used on the Camden & Amboy Railroad, and serves as a type of the construction followed for some years.

In fig. (2) the shell and furnace are both cylindrical, while in fig. (1) the furnace has flat sides and face. Now the cylindrical form may be called the natural shape for a boiler, as this is the best figure for resisting the expansive force of the steam, while the plane sides of the furnace in fig. (1) have to be elaborately stayed with threaded and riveted bolts not more than 3½ to 4 inches apart over the entire surface.

By referring to sketch (9), showing the under surfaces of the furnaces in question, we may see why the simpler gave place to the more complex construction. As the requirements of traffic demanded larger and more powerful engines, the gauge of the track remaining practically fixed, it was necessary to utilize all the available space between the engine frames for the combustion chamber of the constantly growing boiler. This was manifestly impossible with the cylindrical fire-box, and hence it had to give way to its rectangular successor of to-day. Fig. (6) is a rear view of the rectangular fire-box, and shows how the rigidity of the gauge has caused it to appear contracted, the upper portion swelling out beyond the line of the frames. This result is still more marked in narrow gauge engines as now built, some of which look as if made with full gauge boilers, with abnor-

mally contracted furnaces on narrow gauge frames. On some ten-wheel narrow gauge engines recently made at the Baldwin Locomotive Works, the furnace has fairly burst its bonds, so to speak, abolishing the back section of the frame altogether. Fig. (10) shows this construction. The frame ends in front of the fire-box, the latter expanding so as to carry its full width all the way down. The draw-bar is attached to the frame and carried through the ash-pan just under the grate.

Mr. Wootten, of the Philadelphia & Reading Railroad, is responsible for the departure from the usual type of fire-box shown in figs. (7) and (8). The furnace, it will be noticed, rises clear above the frame, spreading beyond it in such a way that a very large grate area is obtained. It is proper to state that the original idea of this construction was to render possible the use of coal dust as fuel. The objection has been raised against this fire-box that it raises the centre of gravity of the engine. This is certainly the case, but whether dangerously so or not, depends upon various conditions, especially the alignment of the road using the engine. I have said that the boiler shown in fig. (1) is the typical American locomotive boiler. The form shown in fig. (3), however, is pressing it closely, and may eventually displace it. In the wagon-top boiler, the portion immediately over the furnace is raised above the shell a few inches to afford steam room, the two parts being connected by an irregular shaped piece called the "gusset" sheet. This part is not only difficult to make but requires staying, to regain the strength lost by departure from the simpler form. In the straight boiler the shell is made an inch or two larger in diameter than in the wagon-top, thus providing for the steam room that it would otherwise lose. Sometimes the straight boiler is made with two domes, but more frequently, now, with one dome placed about the middle of the shell or cylindrical portion of the boiler.

Whatever differences boilers may exhibit in external form, construction of furnace, etc., they are all alike in one respect—they are invariably built on the multitubular plan. This feature of the locomotive has remained unchanged since George Stephenson built the father of road engines—the Rocket. The conditions of the case require the greatest evaporative power in

the least compass, and no better method has yet been devised to effect this, than the multitubular boiler with the forced draught of the exhaust. The variations that we do find between the furnace and the smoke-box of locomotive boilers, are confined to the relative size and number of the tubes and the material of which they are composed. In this country iron tubes are now usually employed, while in England copper is generally used. It is interesting to note that copper fire-boxes are still almost always employed in England, while here we have abandoned copper, first for iron, and now for so-called homogeneous or low grade steel. Turning to the extreme front end of the boiler we find a chamber called the smoke-box, that has recently undergone a curious variation in what is known as the extended smoke-box. Fig. (1) shows the usual form—a cylindrical chamber just large enough to allow the steam pipes, exhaust nozzle and spark-arresting devices to be comfortably stowed away within its walls. Fig. (5) illustrates the new type, and it will be seen that it is simply an elongation of the former type, to perhaps three times its usual length. The object of this extension is to get rid of the sparks and cinders by providing a dead space for the air current, thus allowing the heavy particles to settle. The process is quite analagous to the dead ends of water mains, and I am informed that a certain railroad in New England, using this smoke-box obtains enough unburned fuel—I presume it would be classified as pea coal—from its engines, to furnish all the steam required in its repair shop. The effect of this smoke-box on the external form of the engine is very marked, as it puts the smoke-stack some distance back of its usual position. Should this construction be employed simultaneously with the Wootten fire-box the effect would be still more marked, as the cab and the smoke-stack would then become the central instead of the extreme decoration of the engine. In fig. (4) we have the simplest form the boiler can assume, the upright type. The external walls of the fire-box are not only cylindrical, but they are continuous with the shell. The internal walls are also cylindrical, and the crown sheet and lower tube sheet have merged into one. This form, however, is only applicable to the smallest types of locomotive engines—notably street car motors.

No part of the locomotive has received more attention and thought than what a wagon maker would call its running gear—that is the wheels, their number, arrangement and mutually connecting parts. Starting with a single pair of driving wheels it has attained two, three, four, and even five pairs of driving wheels, as more and more tractive power was demanded of it. The first engines were built with both driving and carrying wheels in a rigid frame, and this practice is still the rule in England. In America, however, the locating engineer of the early roads, was obliged to place his stakes with the "most road for the least money" as his ruling maxim; hence sharp curves, steep grades and unballasted road beds became the rule, and the mechanical engineer had to follow with engines adapted to these conditions.

The carrying wheels were taken out of the rigid frame necessarily occupied by the driving wheels and placed in a truck, the whole carried on a pivot placed centrally under the front end of the boiler. This construction allowed the leading wheels to follow the sharp curves without binding, and reduced the rigid wheel base to the distance between the centres of the front and back drivers. Still further ease of motion was obtained by suspending the bearing block upon which the truck swiveled from links, instead of fastening it rigidly to the truck frame, thus permitting the whole truck to sway sideways four or five inches. An ideal sketch of this truck, known as the swing bolster truck, is shown in fig. (11). Fig. (12) is an exaggerated sketch showing the action of the truck in curving.

XIX.

ON COBBLE STONE PAVEMENTS.

By Prof. Lewis M. Haupt, Member of the Club.

Read June 4th, 1881.

It is customary in organizations of this kind to present a *paper on a subject*, assumed to be of interest to its members; I had hoped this evening to reverse this natural order of things and present my *subject on a paper*, letting it speak for itself, since it is said that there are

"Sermons in Stones,"

but I have been reluctantly obliged to relinquish the idea of presenting it in this way, finding the subject too unwieldy.

In my perambulations about this model "city of homes" my attention has occasionally been arrested by the great diversity of size, form and color of the materials used in paving the streets, and of the very imperfect manner in which some of them performed their functions, so that I have recently looked up the ordinances relating to the forms and sizes of paving stones, and find as follows, June 12th, 1868.

Cubical blocks; "depth of five inches, from four to six inches long and from two and a half to three inches wide."

Rubble pavements; "stones of irregular shape, depth from six to nine inches and length from five to twelve inches with flat top surface having a width at widest part not exceeding four inches."

Cobble stone; "no stone shall be used exceeding nine inches or less than six inches in depth, or showing a greater length of face than seven or less than four inches, and shall in all cases be set close, breaking joint with their greatest length upright and vertical as to position, and shall be rammed until no further impression can be made upon them with fifty-five pounds rammer."

From the above specifications it will be seen that the maximum surface of a "cobble" should not be more than 30 square inches, but as the stone is supposed to be oval and not square, it

would probably not average over 20 inches and its volume not exceed 100 cubic inches.

Now, it is not my intention to cast any reflections upon the present efficient management of the highway department, nor even upon the recent past, and, as we all know from experience, how difficult it is to tell who is responsible for any particular detail of extensive works, conducted under different managements, I shall simply make a statement of facts to show how closely or loosely the inspectors, if there were any in those days, interpreted their instructions.

The single cobble stone to which I desire to call your attention, is located upon one of the principal thoroughfares of West Philadelphia and upon a steep grade. Its greatest surface dimension is three feet and two inches = 38″; its least, two feet and one inch = 25.″ In form it is nearly rectangular; its mean depth is ten inches. The accompanying sketch will give some idea of its appearance.

Its general characteristics are as follows: A compact, homogeneous, silicate with rounded edges; upper surface nearly flat, with concavity near centre, usually filled with dirt or ice; approximate upper area, 675 square inches, about 5 square feet, or over half a yard; volume $5 \times \frac{5}{6} = 4.16$ cubic feet.

Weight 625 *lbs.* (which is sufficient to account for its absence this evening, since the two (2) men I had employed were unable to lift it). Assuming the specific gravity to be 2.5 or 160 lbs. per foot it will give a volume of very nearly 4 cubic feet, which is but little less than that computed from the measured dimensions.

To verify these calculations I selected an average size "cobble" stone and determined its specific gravity to be 2.7 and its displacement to be 58 cubic inches. Its weight in air was 89½ ounces, or 5 lbs., 9½ ounces; hence, if the specific gravities of the sample

and of the "cobble" under consideration were the same the latter was about **120** times as large as the average stone allowed by ordinance.

Its remaining characteristics are:

Age, unknown.
Geological position, diluvial drift.
Genera, boulder.
Species, cobble stone.
Use, paving block.
Locus, south side of Chestnut Street in front of school house, west of 34th.

This, it is true, is a special case, but instances are not rare of large crops of round heads which greatly exceed the limitations of the city ordinance; notably, in front of Nos. 3 and 5 south 34th Street; on Woodland Avenue west of 34th; on Market Street east of same, and at many other places.

A few words concerning the applicability of "cobble" stones to the requirements of a good pavement may not be out of place.

If two such spheroidal stones be held in contact, with their longest axes vertical, it will be seen that since the surfaces are "double-curved" there will, in general, be but a single point of contact, and hence, for all practical purposes, no friction; and if one such stone be surrounded by others of various sizes and forms, there will be as many points of contact as there are adjacent stones, but these points will very rarely lie in the same horizontal plane, some being above, some in and some below the plane through the centre of gravity of the given cobble. Hence any lateral disturbance of any one of the surrounding stones will tend to produce rotation of the middle one. A vertical disturbance will likewise produce a similar effect, by increasing or reducing the lateral pressure.

The stability of a "cobble" stone pavement is therefore almost solely dependent upon the firmness of its bed, and the wedging into the lower interstices of the gravel upon which it is supposed to be laid.

But this gravel is composed of a certain percentage of loam which retains the moisture so freely admitted through the numerous voids in the pavement, and no matter how firmly it may

be laid in dry, warm weather, the enormous expansive power of clay when wet or of water when frozen, will lift it bodily during the succeeding winter. The heat of the following spring causes the substratum to dry out and shrink away, leaving the surface stones in many cases unsupported, and the consequence is, that in a few weeks the so-called pavements are cut up into grooves and ruts, somewhat resembling a ploughed field with large quantities of loose "cobbles" lying on the surface, rendering it necessary to repave a large portion of the streets every spring.

I do not propose to discuss here the numerous and conflicting requirements of good pavements for carriage ways, but from what has already been said, it will appear that the durability of the structure is directly proportional to the size, that is, mass, of the blocks of which it is composed, yet the danger to horses from insufficient foothold is inversely proportional to the size, and of all possible forms that could be devised, the "cobble" stone is the most unstable, unsafe and unclean. Its only recommendation is the low price at which it can be laid, but the cost of maintenance, if properly done, will make it as expensive as the best Belgian block laid upon concrete foundations, or the still better compressed asphalt, so far as our experience with it goes.

The Belgian blocks described in the ordinance are too short and narrow, requiring stones which are too light and causing too many longitudinal joints, which are the weakest points of such pavements. The manner of laying them in transverse courses is also objectionable, causing greater wear; they should be laid diagonally. The rubble stone pavement is simply barbarous and should not be permitted under any circumstances, for although more durable than "cobble" stones it is much more severe on horses and vehicles.

DISCUSSION OF PAPER VII., VOL. I.

By the Author, PROF. L. M. HAUPT, Member of the Club.

Read June 4th, 1881.

THE RELATION OF SCALES TO EACH OTHER.

In a communication recently received, relating to my paper on the scales of maps, published in Vol. I, No. 1, of the Proceedings, a friend remarks, "considering that the matter of the scale of a plan is one of the most familiar things to all engineers, and involves only the slightest fundamental and almost axiomatic mathematical conceptions, I think it is remarkable how easily men can get confused over it. If one is entirely unfamiliar with some particular practice in regard to it, it requires a mental effort to judge impartially of the merits and demerits of that practice, and Mr. Coleman Sellers is cited as saying, 'There is reason in all things, even in scales.'"

Accompanying this letter was a copy of the Rules* adopted in July, 1878, by a Board of Railroad Commissioners for one of the states down East "in regard to Records of Railroad Locations, and the manner of keeping the same," and my attention was called especially to Rule 1, which reads as follows:

"Location Maps hereafter filed shall be made upon *a scale of*

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*RULES

Prescribed by the Board of Railroad Commissioners, under Chapter 135 *of the Acts of* 1878 *in regard to Records of Railroad Locations, and the manner of keeping the same.*

RULE 1. Location Maps hereafter filed shall be made upon a *scale of not less than four hundred feet to the inch,* upon cloth-backed paper, and shall be firmly bound for record in books eighteen (18) inches from top to bottom, and thirty (30) inches from back to front.

RULE 2. Said maps shall show the courses of the tangents and the radii of the curves of the centre line of the railroad in question; the widths of land taken, specifying such width on each side of the centre line; also the courses of the division lines between the lots over which the location is made, and the distance between them on the centre line. Where but one track is laid, the position of such track with reference to the centre line shall also be shown, in order that the boundaries of land may hereafter be determined by measurements from the track as laid, if the same shall not have been changed. Where two tracks are laid it may be presumed that the centre line is midway between them. NOTE.—The *courses* called for above

not less than four hundred feet to the inch, upon clothbacked paper, and shall be firmly bound for record in books eighteen (18) inches from top to bottom, and thirty (30) inches from back to front." In commenting upon the above rule, my friend says: "I defy you to determine from Rule 1, as actually worded, whether the commissioners forbid scales to be larger or smaller than $.00020\frac{5}{6}$ of full size * * *" and he adds further on, "I consider,

4 stations to the inch.	As inviting ambiguity more than	$\frac{1}{4}$ inch to 1 station.*
16 feet to one inch.		$\frac{1}{16}$ inch to 1 foot.
5 meters to one centimeter.		.002 meter to 1 meter.
$\frac{1}{4800}$.		$.00020\frac{5}{6}$.
1: 3333.		0.0003: 1.
3333: 1.		1: 0.0003.

I put the last three items rather to show what mathematical expressions we should be led to by analogy than because I regard either of them as really inviting ambiguity. My reason for preference in the first three illustrations I think valid, and incontrovertible, though of less importance than another reason which leads to the same preference.

My criterion is very similar to your statement in your paper on the Scales of Maps that 'the given material object to be represented by the map or drawing is the unit of measure, with

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may be either *magnetic* or *true*, but the maps and descriptions must specify which are given.

RULE 3. The maps shall be certified by the Directors of the Corporation.

RULE 4. The description in writing must in all cases correspond with the map, and the two taken together must have the substantial certainty and precision of a deed. (II Gray, 580.)

RULE 5. The maps, when deposited with the Clerk of the County Commissioners, shall be kept for preservation and convenient reference in the office of said clerk, in a cabinet used exclusively for that purpose, and furnished with shelves sufficient to allow at least one separate shelf for the maps of each corporation owning a railroad within the county.

RULE 6. A book shall be kept in the office of each clerk, in which shall be recorded the name of every location, the time when it was filed, and the shelf where it is deposited.

RULE 7. No location after it has once been filed shall be taken from the office of the clerk for any purpose except upon the order of a court or other proper authority.

* Here meaning by station 100 feet.

which the other is to be compared;' but as you are pursuing a different line of enquiry you are led to a different practical result from mine. If you should hereafter * * * discuss the same subject in some other treatise, or before your pupils, I hope you will give it a careful revision.

In replying to this communication I have said among other things as follows:

The doubts concerning the meaning of Rule 1, I venture to suggest, arise not because of any possible misconception of the term "400′ to 1″" but from a misapprehension of what is meant by the words "less than" as there used. Now 300 is manifestly *less* than 400, but as such a scale would present the objects *more* clearly than the other, it is evidently not the intention to exclude it. The intention must be to prevent a too minute representation of the objects, by using a scale containing *more* than 400′ to 1″.

What do we mean then by a larger or smaller scale? Simply that the representation of the object shall be larger or smaller. And it is made larger by taking a *smaller* number of its linear units to one inch or other unit of the drawing. The difficulty here is the same as that which presents itself to students in making corrections for measurement made by an incorrect chain. They suppose if the chain is longer than the standard they must subtract the error, and if shorter add it, forgetting that the chain is a divisor, and the line to be measured a constant dividend, and that if the divisor be too great the quotient will be too small, so that if the chain be too long the error must be added and not subtracted.

Hence a scale of 100′ to 1″ would be technically a *larger* scale than one of 200′ to 1″ although the units expressing the ratio as above given are smaller; but if it be remembered that the first quantity is a divisor and that the *scale is a ratio* expressed in the form of a fraction as $\frac{1}{100}$ or $\frac{1}{200}$, no doubt can exist as to the first being the larger fraction, for the quotient of the first by the 2d is 2.

If it be remembered then that a larger scale means larger representations of objects in the drawing, the intention of the rule becomes clear, and it may be written thus:—*Maps* . . .

shall be made upon a scale (such that the objects which they represent shall) *not* (be) *less than* (those given by a scale of) 400′ to 1″.

My preference is to express scales by the vulgar fraction rather than by the decimal, as being indicative of the original units used in the ratio. For example $\frac{1}{4800}$ shows at once that it is 4800″ to 1″, or ÷ by 12, 400′ to 1,″ while its decimal equivalent .00020$\frac{5}{6}$ shows nothing until the scale is actually drawn and divided up, after first reducing it to its original vulgar fraction, to obtain the units of division.

You confess that it is remarkable how easily men get confused over so simple a matter. Permit me to suggest, that it is because of the ambiguity as to the meanings and applications of the terms used, that this trouble arises. If you will try the simple rule laid down in my paper, and express all scales thus $\frac{1}{n}$ taking n as the object, and using it invariably as the antecedent or divisor, all difficulties will vanish.

A *larger* scale will then be $s = m \times \frac{1}{n}$ where m is a whole or mixed number or improper fraction. A *smaller* scale will be represented by the same formula when m is a proper fraction. By this method it will appear that the expressions of the scales increase or decrease in value as the lines on the drawings vary, and there can be no confusion.

Thus, to reduce a drawing to ½ size of original make, $m = \frac{1}{2}$, and the formula becomes $s = \frac{1}{2n}$ from which it appears that the number of units of the object represented by 1 inch of the drawing must be doubled. For a drawing ⅔ the size of the original we have $s = \frac{2}{3n}$

To determine the relation between the scales of two maps is also a very simple matter when expressed fractionally. Thus let one of the scales be $s = \frac{1}{n}$ the other $s^1 = \frac{1}{m}$ the ratio will be $\frac{s^1}{s} = \frac{n}{m}$

If $m = 2n$, then $s^1 = \frac{s}{2}$ or the scale s^1 is ½ of s, care being

taken that the unit of map length be the same in both cases, as 1 inch or 1 cm.

It should also be remembered that the terms enlarging or reducing drawings are applied to their linear dimensions only, and not to the areas or surfaces which they may represent or contain, for these must vary as the squares of their homologous lines.

XX.

THE GRAND WATER WAYS OF PENNSYLVANIA.

By Col. James Worrall, Member of the Club.

Read June 15th, 1881.

All engineers who have any love for their great profession and have read over its meagre history, are aware that that history is scarcely to be found in books; its pages are composed of everlasting works, lasting at least as the material of which they are composed. It tells its story as the "stones of Venice" prate of its architecture, nor are there any trumpeters in the profession. But what engineer has forgotten the reply of the grand old Brindley, the man who used to retire to his chamber in the daytime, and close the shutters in order that he could construct his works from corner stone to cope in darkness and alone. For was it not a saying of his that unless a man *could* so construct his works and foresee them finished in the sable loneliness of his chamber, supine on his couch, before a blow of the pick was struck in the field "he could not construct them at all." No engineer who ever heard it can forget his reply to the committee of Parliament. After a few enthusiastic remarks of his on the subject of rivers, and seeing how he was wrapped up in the subject, "Why Mr. Brindley," said one of the committee, "what do you suppose rivers were made for?" "To feed navigable canals" was the immediate answer.

And so indeed it is natural for an engineer to think, and let this be the text of what I have to say this evening.

Rivers were made (amongst other things) as a means of assisting man in his transportation: Nor can their assistance be rejected, for undoubtedly they afford the cheapest inland medium for that vital necessity. In a word the material of which rivers are composed cannot wear out; whilst there is nothing else over or through which transportation can pass, that not only does wear out, but the renewal of which is costly in comparison with the expense at which rivers can be availed of. There is less friction in river transportation than in any other, and as I have elsewhere stated (a mere truism by the way) friction may be set down as almost the sole cause of labor and cost in this world. Accordingly we find almost universally all over the earth, that wherever man is invited to congregate on the earth's surface, by fertility of soil, and geniality of climate, these rivers are to be found, and most especially where minerals are added to the wealth of the soil rivers almost invariably exist leading from the region of deposits to the region where the minerals are wanted.

In every coal and iron region known, there are to be found the heads of streams running towards the ocean, and the ocean itself is a ready made water way to all parts of the world. Water transportation then will never be abandoned. It is a necessity like any other universal necessity, like fuel, the metals, the crops, etc. Pennsylvania is as attractive a lot of land inviting population as any other lot of the same size in the world.

Its rivers are capable of being improved to the most effective state of navigation. Its soil almost "anticipates the labors of the husbandman," and the ore of all the useful metals and deposits of the best kinds of fuel are to be found almost "struggling through its surface."

Where are all the great commercial cities to be found? Invariably at or near the mouth of some important stream which permeates the back country and brings down the products of the valleys for shipment on the ocean to other countries where they are wanted.

When William Penn came to examine the location of that magnificent rectangle granted to him by Charles II, the first feature he looked after was the location of its streams. He found the Susquehanna and its branches inviting transportation and

extending over the eastern half of the territory, and the Ohio and its branches equally draining the western half; the territory being divided almost equally by the Allegheny mountains passing through it on a diagonal from N. E. to S. W. the one half of his grant sending its products to the Mississippi valley, and the other half to the Chesapeake Bay; whilst a considerable corner contributed its quota *via* the Delaware river,—and as if that was not enough; streams heading in Pennsylvania debouched into the lakes; so that the delivery ports of Pennsylvania were to be found thousands of miles from each other. Some upon the waters of the Gulf of St. Lawrence others upon those of the Gulf of Mexico; whilst the Delaware and Chesapeake bays both attracted commerce in their direction. He found that the Susquehanna waters the very centre of his empire, or as he called it, his commonwealth; but he also found that the Susquehanna led the products south of his jurisdiction. He saw this disadvantage almost as soon as he got his first maps drawn and immediately sought a remedy. His first idea was to establish his seaport at Chester, which had a fine harbor and was far enough from the ocean not to be affected by its storms. But the Susquehanna drained his territory, and rival ports might spring up below its mouth on the Chesapeake bay, and deprive him of the advantage to be derived from a seaboard city in that region. His attention was then attracted to the Schuylkill by means of which he might cross the divide and intercept the trade of the Susquehanna, at a point say 80 or 100 miles above the mouth. He then changed the location of his commercial depot to the mouth of the Schuylkill, depending upon an artificial navigation inland to the valley of the Susquehanna.

It must be remembered that even at that day internal navigation was not a new science by any means. Some of the most perfect canals in the world had long been constructed and were in full operation in France, Italy, and in Holland; canals which have scarcely been improved upon at the present day. The greatest engineers the world has known had lived before William Penn's time. The beginning of the Sixteenth Century amongst the immortal artists which it had produced had not forgotten engineers, and works constructed at that time were in

principle as perfect as any works of the kind existing at the present day. Some of the greatest of the artists (painters) of that time were also both engineers and architects, as witness the Angelos and the Da Vincis. So William thought he could remedy by art the accident which lead the streams of his territory out of it, and thus Philadelphia was located where it is. Penn's idea was not forgotten by his successors. Rittenhouse, Franklin, and other great scientists kept their eyes constantly on the idea of diverting the trade of the Susquehanna to the Delaware by artificial means, and the Schuylkill through its improvement was to aid in this expedient. It was even then hoped that a canal could be constructed to the lakes by the aid of the Schuylkill and the Susquehanna, and if any one will examine Franklin's, he will find therein a clause leaving some 10 or 12 thousand pounds to aid the great undertaking.

But turnpikes sprang into existence, McAdam, first called the Colossus of Roads, an addition since inherited by others, immortalized himself with his broken stone ballast as it was called, and the "Conestoga wagon," carrying a ton to a horse, served as an intermediate expedient between common roads and canals. The turnpike was less expensive than the canal in original construction, and proved to be capable of turning aside a large portion of the trade, which trended down the Susquehanna to Baltimore. The Conestoga was actually believed at the time to be the perfected means of transportation. The great Philadelphia merchants, many of them, believed that it could not be improved upon, and Pennsylvania vibrated with the bells of the great London dray horses; the Barclay and Perkins breed which had been transplanted to our turnpikes, and carried the products of the interior to Pennsylvania's seaport. These horses were indeed the finest draught horses in the world, from Normandy originally, perhaps destriers or war horses that in the days of chivalry had

> "Fieldward borne some valiant knight
> And champed 'till bit and boss were white
> Yet foaming, must obey"

reduced at last not to chronicle "small beer" indeed but to deliver it in far different casq(*ue*)s from those their former masters wore.

The turnpikes and the grand old "entire" horses and McAdam's smooth ballasted way, did not come any too soon to effect their object. Already had the wheat of Pennsylvania brought down the Susquehanna, given celebrity to a Baltimore brand of flour. "Howard Street" was known over the world wherever our products went; and not until Pennsylvania turnpikes had by their deliveries equalled that brand in Philadelphia, did its special superiority in reputation disappear. Turnpikes indeed caused an almost perceptible drawback to the efficiency of canals; canals were always expensive and we had not the means to make perfect ones in this country. So, as it were, they were involuntarily set aside, until the Erie canal was finished, when they began to look up again. The enterprise that created the Erie canal was emulated in Pennsylvania, and although the physical difficulties in the way of their construction were many times greater in Pennsylvania, yet a "Main Line" was constructed here, and the advantages of the turnpike were improved upon to preserve the ascendency of Philadelphia as a Pennsylvania entrepot for the products of her own territory.

Canals were gradually perfecting themselves and aiming at the permanence and efficiency of works of the kind in Europe. When almost at this moment of time the railway with its locomotive came into play. Its wonderful per centage of facilities asserted themselves immediately. The public was astonished and magnetized as it were by the close approach to the annihilation of space which was effected—and the canal stood still. The railroad took transportation to itself everywhere, the Norman destriers were sent back to the breweries, or left there, or became farm horses and were harnessed to the plough or the harvest-wain —the canal stood still—neither its construction nor its facilities attracted the inventive genius of mankind; whilst every man who ever thought to immortalize himself by an ingenious application of the mechanical powers directed his mind to this new and wonderful method of transportation. And so it is to this day, the canal is standing still and the railway is improving year after year. But there remains by its side an inevitable and everlasting tendency of things. No matter how great may be improvement; no matter how facilities may present themselves;

there is one eternal principle remaining, which regulates everything in this world of a material nature; and that is COST. If any one thing here below be more cheaply attained in one way than in another, the cheaper way must eventually be preferred. The cause of the decay of nations in all history is COST. Facility attains preference for a time, but cheapness conquers in the end. All great nations only became great through their economies.

Could Venice ever have risen out of the sea had she not furnished mankind what he wanted more cheaply than any other nation could do? Could England ever have attained her commercial preeminence unless she had attained that preeminence by offering better facilities to the world than could be elsewhere attained and at a lower cost. Venice preceded her, Amsterdam preceded her, Lisbon preceded her. But the Cape of Good Hope was doubled, and as soon as England found that orbit to the East, and by her superior seamanship could obtain goods from the east by that line and sell them cheaper than the rest, the rest went down or stood still, while England took precedence. True England conquered and monopolised the productive territory, but she never could have done that had she not previously attained facilities through the multiplicity of her customers whom she had attracted to her marts by cheapness.

What explains the wonderful advance of our own country at this moment? Why does the rest of the world turn attention to us now? It is because of cost. They get things cheaper, all other things being equal, from us than from others. Therefore let it be remembered that cheapness conquers in the end. All mankind are compelled by the laws of nature to struggle for an existence here. Man pays for it by the sweat of his brow; and he will fulfil the obligation that is upon him at the lowest cost and the smallest exertion. The precious metals are its measure of value, he knows the labor it costs to attain them; and strange to say, that amount of labor has never been known to vary to any great extent. Every ounce of gold in the world, if its average cost was known or sought and found, that cost would equal about fifteen days of manual labor, and every ounce of silver would be found to have cost say one days similar work. This has been true throughout man's experience, and it is true now. As these

metals then are the measure of the value of existence on this earth, is it strange that all things should be regulated through them. Fifteen days of a man's existence must be expended in attaining an ounce of gold, or one day of the same an ounce of silver. And this rule has been found in all experience to be essentially unalterable. Existence is the most important thing to him that man can imagine, and whatever affects that is intrinsically essential to him; but existence can be reckoned in so many ounces of gold and silver because it is sustained indirectly by these. Are not then gold and silver the measure in value of every conceivable material thing or state of things while mankind remains?

Transportation is one of the great interests of mankind, it is auxiliary to his very life, as the kindly fruits of the earth are and its cost in gold and silver is one of the elements, the importance of which cannot be changed or avoided, and the cheaper mode must eventually be preferred to the dearer.

It costs a man fifteen days work to attain an ounce of gold. How much of such labor does it require to transport a ton of goods through a mile of space? Transmute that labor into gold; and of the expedients adopted to effect that transportation, the cheapest will be chosen in the end. This is a law of nature and cannot be set aside any more than the laws of gravity can be avoided. It stands to reason as I have before said that water is not worn out by a vehicle passing through it, and the vehicle is but little worn by the gentle friction it experiences in passing through water. It is true that water runs away and must be replaced at some cost, but such cost can be previously ascertained to a very close degree of nicety, and that replacement is certainly cheaper than the replacement of so much iron or steel used for the same purpose, let the iron or steel last as long as either may. Iron bearing on iron to the extent of many tons to the square inch, and moving at a high velocity, must have a reciprocal wearing effect, scarcely comparable to the wearing effect upon a boat passing through water. This truth cannot be got rid of by any conceivable arrangements or circumstances, and water transportation must be cheaper than any other system as yet discovered. But at present there is a furore in favor of

railways, on account of their magnificent velocities and on account of the unexampled activities of mankind at this time, which they have mainly caused. There are arguments in their favor: where velocity is of preponderating importance. Nor will they be thrown out of use unless the power of navigating the atmosphere safely should be attained.

But for the transportation of tons of dull matter they must be set aside in favor of canals, where there is no special hurry, and canals will revive as certain as fate. Had the same amount of mechanical genius been applied to the improvement of canals which was and is applied in reference to railways, we should be using the latter now much more extensively than we are. Economisation has scarcely yet been thought of in their use. But let them again come into vogue, and we shall find them saving water automatically, in which case it is plain that they can be used in many places where as yet they have scarcely been thought of.

The subject of water transportation has been brought to the attention of our people in these latter years, and many projects have been revived which were supposed to have long since been relegated to oblivion. For grand communications from the interior to the seaboard, the physical geography of Pennsylvania is not by any means unfitted. The upper branches of the Mississippi valley (some of them), are found within the territory of Pennsylvania, and indeed the same may be said in respect to the Laurentian valley; the two grand outlets of our grand continent—the one debouching into the Gulf of Mexico and the other into the Gulf of St. Lawrence. Can these valleys be tapped and their vast wealth, a portion of it, attracted to intermediate ports on the Atlantic?

There are many points where both valleys can be tapped both north and south. The Erie Canal has tapped the lakes, the St. Lawrence valley and the Ohio may be connected with at various points from its mouth upwards; the uppermost and not by any means the least important or economical point being Pittsburgh.

And indeed the lakes may be connected with the Atlantic ports of Pennsylvania. She is, besides, a competitor with Vir-

ginia in respect to the middle Ohio, and may compete with New York in drawing toward her seaboard a considerable quota of the lake trade.

It has been seen that streams heading in Pennsylvania fall both into Lake Erie and Lake Ontario. These streams head within a few yards of other streams which fall into the Atlantic *via* the Delaware and Chesapeake bays, and indeed into the Mexican Gulf. And the highest elevations to be overcome average from 1400 to 1700 feet above the level of the sea, the elevation of the Ohio at Pittsburgh being 700 feet.

If water is attainable, lockage amounts to the delay of passing locks, and as it is as easy to measure the available water of a piece of territory as it is to measure its area the question of water can always be settled. It is remarkable that the immensely rich mineral territory of Pennsylvania is permeated by streams which can be made navigable, and these streams can be so improved as to connect with great lines running either east or west, *i. e.*, to the Atlantic or to the Mississippi valley or the Laurentian valley.

The Congress of the United States took up the subject of the location of the great water lines from the interior to the seaboard, and the attention of the States interested was drawn to the subject in 1873–74. The States were called upon for a specification of their claims, and Pennsylvania replied by indicating three grand trunk lines that might be made through her territory, two from the Ohio valley to the Chesapeake Bay, and one from Lake Erie to the same point of tide water. Members of Congress asked for appropriations to survey or explore the different lines, and accordingly in 1878, 1879 and 1880 appropriations were made with that view.

The writer of this paper, incidentally by a letter to General Simon Cameron, at that time Senator from Pennsylvania, specified the routes,* and by mere accident was afterwards called upon to verify his specifications by actual surveys. Reporting to Cols. McComb and Merrill of the U. S. Engineers, who had been

* See Senator Windom's Reports on Routes to the Seaboard, 1874, Vol. 1. p. 234, and Appendix, p. 96.

charged by the Chief of Engineers with the explorations. It will be seen by the pamphlet submitted herewith, that the surveys were made and the Reports published by order of Congress, which were reprinted by resolution of the Legislature of Pennsylvania, session of 1881. The club is respectfully referred to the latter publication, in which it will be seen that the routes have been gone over with some degree of care, and that should canals ever again come into vogue, of which the writer has not the slightest doubt, Pennsylvania lays claim to routes which cannot very reasonably be ignored or set aside.

The Ohio at Pittsburgh can be connected with the east, either *via* the Allegheny, Kiskiminetas, the west branch of the Susquehanna, and the Juniata, or *via* the Allegheny, the Red Bank and the west branch of the Susquehanna; and the Lakes can be connected with the same point, the head of Chesapeake Bay by a branch from the Erie Canal at Montezuma, about 150 miles east of Buffalo *via* Seneca Lake, the Chemung river and the north branch of the Susquehanna.

The first two connections being respectively say 355 and 425 miles long. the third being measured from Buffalo, some 520 or 530 miles long. The first two will be equal in cost, or say $40,-000,000 each, the latter, although longer line, has been set down at $25,000,000. There is a large portion of the last in length which will hardly require expenditure at all, that distance being estimated at over 100 miles, and being composed of the long level on the Erie Canal, about 70 miles, and Seneca Lake, which is 37 miles in length. So that the Northern line requires new construction on no greater probable length than either of the others. Hence, the comparatively smaller cost of the Lake line.

The ideas contained in the pamphlet report submitted herewith it will be seen are not new. The subject was agitated extensively more than half a century ago, and the highest engineering talent of that day was consulted with favorable results. Hydraulic engineering was at its height at that time, indeed for centuries before. Hydraulic engineering in the ancient time created nations; and when its exertions were withdrawn the nations decayed.

The same science will resuscitate the same nations, and others

in both hemispheres, when again consulted and brought into play. So that an old opinion from that source is perhaps more valuable than a new one.

The statements of the pamphlet then may be said to be sustained by the highest scientific authority, old although it be. And water ways may yet permeate the United States, notwithstanding the present ascendency of railways. That railways will be seriously affected by such a state of things need not be feared. There is ample work for both modes of transportation. The railways will only give in where they are beaten by cheapness. It is subtracting from the accumulating wealth of the material world to adhere to a dearer mode of transportation, and the inevitable laws of economy must eventually be obeyed.

This principle shows itself in many places. The scrap heaps, or rejected debris of old iron works and mines, are now being raked over profitably for the sake of bringing to life again what was thrown away as not worth overhauling. And who can doubt for one moment, that the immense amount of gas and oil now suffered to escape in our oil regions, making the surrounding atmosphere almost inflammable will eventually be economised to the last cubic foot of the one or gallon of the other. Whilst on our railways the power which is now sacrificed to velocity, without feeling the loss, will be applied, every pound of it, to the transportation of things economically from one point to another.

We all know that velocity is attained from the same source as the power which propels heavy weights slowly, a force constantly and reciprocally transmutable, there is no real necessity for an ounce of that force being lost. It is all due to heat, no single degree of which need necessarily be thrown away. Keep up the railways then to transport yourselves, your letters or your fine goods, but let the ponderous products of the mine or furnace be urged forward without unnecessary velocity, whereby the material of which your goods and your vehicles are composed may both last, fulfilling their utilities, until they are worn out by economical use and not frittered away in an idle display of useless and uncalled for hurry.

Respectfully submitted with the Reports on the Grand Water

Ways of Pennsylvania, printed by order of Congress, and reprinted by resolution of the General Assembly of Pennsylvania; Session of 1881.

DISCUSSION OF PAPER X.

INTERCOMMUNICATIONS IN CITIES, ETC.

Read by Prof. L. M. Haupt, Member of the Club, January 15th, 1881.*

BY DR. H. M. CHANCE AND PROF. L. M. HAUPT, Members of the Club.

DR. H. M CHANCE, May 7th, 1881.—Prof. Haupt truly says: "It is one of the duties and privileges of engineering societies, knowing the possibilities of their profession, to consider and suggest plans and projects which tend to ameliorate the condition of the communities in which they are located," and I also hold it to be as great a duty and as high a privilege, to discuss the "*pro's* and *con's*" of all such suggestions or plans. In his able and instructive article he has approached the subject from a purely financial and business point of view, and has dealt with "*time, space and power*" as though these were related in their bearings, not to men, women, and children, but to machines; and to such the conclusions might be applicable, but we are more than machines, we need air, and light and space, and any conditions reducing these to less than a certain fixed quantity, aggravates rather than "ameliorates" our condition.

It may be well to discuss some of the proposed improvements from a sanitary and moral standpoint,—one that demands more "space" than from the mechanical consideration might seem necessary,—but I would first discuss some of the reasons that have been advanced to show the necessity for the diagonal system, and I think that after they have been analyzed, they will not seem so cogent.

It is true that every person, desiring to, travelling in a diagonal course across a rectangular system of streets must lose 42 per cent. of the time actually necessary to accomplish the air-line

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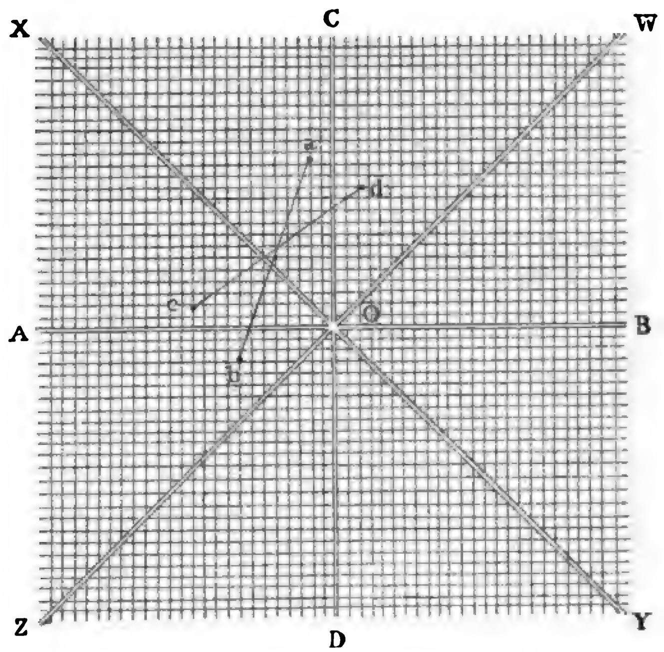
* Page 115 of this volume.

distance, but the saving to such by the opening of a diagonal thoroughfare amounts to but 29½ per cent. of the time and distance he formerly travelled.

Comparatively few of the residents of a city can avail themselves of the diagonal cut-off for more than a fractional part of the distance they have to travel, and if we investigate this subject more closely, we will find the actual saving much less than might at first sight appear.

Let us suppose an ideal city built on the rectangular plan with diagonal thoroughfares, and inquire into the per centage of distance saved to the travelling public.



The annexed cut shows such a city consisting of fifty main streets running north and south, and fifty main streets east and west, running parallel to the main thoroughfares A. B. and C. D. The main streets are supposed to be 400 feet apart from centre to centre and 60 feet wide. The business centre is located at O., the centre of the city.

This city will contain 2500 blocks 340 feet square, and each

block will furnish sufficient building area to comfortably house 400 people,—the total population being one million.

If we estimate the possible economy of time and distance accruing from the opening of the diagonal thoroughfares X. Y. and W. Z. by supposing that one hundred persons travel daily to and from each block to the business centre O., we find the distance travelled before the opening of the diagonals is 984,848 miles, an average of 3.94 miles for each person; but after these thoroughfares are thrown open the distance is lessened to 798,912 miles, an average of 3.20 miles for each person,—a saving of about 18⅝ *per cent.* (of distance).

But as much of the travel will not be towards O., but in directions nearly at right angles to the diagonals, as from *a.* to *b.* and from *c.* to *d.*, the above is evidently in excess of the actual average per centage of distance saved. Again, much of the travel will necessarily be in a direction nearly coincident with the course of the rectangular streets. Assuming that this direct travel and that across the diagonals amount to but one-fourth of the total travel, the 18⅝ per cent. is reduced to 14⅓ *per cent.* of the total travel,—a saving in distance of 2957 feet, equivalent to 6 minutes in a street car, or ten minutes on foot *per diem* for each person.

In these estimates we have assumed an equal distribution of the residences of business men throughout the city, but this never exists; each man chooses for his residence a locality within (to him) reasonable distance from his place of business, one that can readily be reached by some line of street cars or other conveyance, and the average distance travelled is thereby greatly lessened. The machinist usually resides within a mile of the shop; the weaver walks but a short distance to the mill; and it is (as a rule) only those who can afford the time, and can enjoy the walk, or profit by the morning ride to read the newspaper, that reside at considerable distances from their places of business. An allowance af 3.94 miles per day is probably in excess of the average distance travelled by one-fourth the population in going to and returning from their places of business,—and on this basis the maximum saving has been shown to amount to 6 or 10 minutes, no deduction being made to compensate for any

reduction of the total distance by reason of the proximity of residences to places of business.

In these estimates every advantage has been conceded that could possibly accrue from the diagonal thoroughfares in a city in which the business centre is at the intersection of the diagonals, and the maximum saving in time and distance is found to be 14½ *per cent.*, but the proposed system could not possibly accomplish so great a reduction in the distance travelled in Philadelphia,—for the following reasons:

1. Philadelphia has several business centres, and the directions of travel do not (at present) converge toward Broad and Market.
2. The Pennsylvania avenue thoroughfare would be a convenience to the comparatively small per centage of the population residing between the Schuylkill on the west and a line drawn midway between Pennsylvania and Ridge avenues on the east.
3. The Francis street diagonal would be an accommodation to a very small per centage of the travelling public.
4. As but a limited number of railway companies could lay tracks or run cars on the diagonal thoroughfares, the saving in distance and running expenses to these corporations would be comparatively slight.

Even assuming that the railway companies save as much in distance as the foot passengers in our "model city,"—an average of 2957 feet,—this would amount to but one-quarter of a million dollars, and as these thoroughfares would lessen the distance to be travelled they would probably lessen the number of persons carried by the companies to an extent that would probably "wipe out" this $250,000. The benefit to the street railway companies is hardly worth considering, the travelling public would be the real gainers.

The economy of time, and the distance saved, although under the most favorable circumstances amounting to but 14½ *per cent.*, certainly make diagonal thoroughfares a *desideratum*, and in designing city plans these advantages should not be forgotten,—but is it advisable to open such thoroughfares in Philadelphia?

In this city the distance saved would probably be not more than half the maximum of our "ideal city" or about one-quarter of a mile for each person compelled to travel daily between

his residence and place of business,—equivalent to three minutes in the cars, or five minutes on foot.

Prof. Haupt states that his plan of opening diagonal streets would displace 1½ per cent. of the population of the district through which they ran, but as they would increase the building lines by more than 7 per cent. the number of people who could find residences in the district would be increased. He also says: "At present many of the blocks are simply 'hollow squares.' By opening or enlarging streets through them, the available building area would be largely increased without at the same time crowding out any of the population." No, the population would not be "*crowded out*," they would be *crowded in;* crowded into houses without yards or gardens, crowded in between walls that shut out the sunlight and the pure air needed by all; crowded so close that contagious diseases would more easily spread, so close that there would be no play-yards for the children, no room for flowers or trees. And would this pay? Yes, —financially.

It is the boast of all those who are proud of our city, that she is a *city of homes*, not tenement houses. Our houses are roomy and comfortable, and what city has yards and gardens comparable to ours? The benefit the children derive from the yard or garden is inestimable. In it they have a place to romp and play under their mother's eye, removed from the dangers and the demoralizing influences of the public streets.

Crowding means disease, immorality and death,—can we afford to court these visitors for the paltry gain of three or five minutes a day?

Will it be wise to take the space now occupied by yards and and gardens, for new streets and building lots on which the houses must stand so close that the sunlight can rarely find its way into them? These are problems of serious interest.

If more building lots are needed they can easily be found; to the north, the west, and the south are miles of unoccupied ground, and to make this available, the railroad improvements suggested by Prof. Haupt, together with the building of three or four rapid transit roads,—either elevated or underground,—will go far towards solving this difficulty.

The health of a city, other things being equal, will vary inversely as the density of the population, and the sanitary engineer must always strive to lessen rather than to increase this density if he is working for the well being of its inhabitants.

By Prof. L. M. Haupt, May 21st, 1881.—At the close of his recent remarks upon this subject, Dr. Chance kindly handed me his paper, with the request that I would reply to it. This I now proceed to do as briefly as possible, realizing the fact that protracted discussions are apt to become irksome and uninstructive. I desire to thank him for the interest he has taken in the subject and for the emphasis which his paper gives to the beneficial results of my proposed improvements. We are agreed concerning the end to be attained, viz., the enhancement of the welfare of the community; neither do we differ as to the special means proposed, except in degree. Dr. Chance apparently supposes that I have largely over-estimated the beneficial results of my plan, and evidently misunderstands my statements, so that, starting upon an erroneous assumption, he proceeds to scale down the percentages of benefits by a series of purely hypothetical considerations until he reaches apparently very insignificant results.

Now I propose to show that his estimate is not comparable with mine for the following reasons:

1. His data are entirely arbitrary and are applied to a special case, different from that which exists in this city, and his percentages of resident and moving population are also assumed, whilst the data in my paper are based upon actually observed facts, as reported by railroad and other companies, by census returns, and upon distances measured on the city plan.

2. His "ideal" city has an area more than four times that of the portion of Philadelphia to which my proposed diagonals apply.

3. His results are given in the per diem saving to the individual, whilst mine are the aggregate per annum.

4. Whilst objection is made to the diagonals as tending to increase the density of population, it should be observed that in

his "ideal" city he *comfortably* houses 400 people in a square 340 feet on a side, giving only 289 sq. ft. for each person, which is a greater density than that of any ward in Philadelphia, either at present or under the proposed new system, and yet his argument is based upon the alleged fact that I have discussed the question merely from an engineering standpoint, and as applicable to machines and not men.

These points I will now consider briefly in detail.

1. Dr. Chance appears to be under the impression that I have based my estimated benefits upon 42 per cent. saving of distance and applied it to the entire resident population, for he explains that the saving is not 42 but 29¼ per cent., and that this is applicable only to those persons whose terminal points are on the diagonals. This I concede, and it is what I have said in several papers on this subject. I regret that my language seems to be so ambiguous as to have misled any one. As my remark on page 118 of the Proceedings, Vol. II., concerning the 42 per cent. seems to have originated this discussion, "I rise to explain" that, by "distance between termini," I mean of course the air line, and that the extra distance which one is obliged to travel in consequence of the *non-existence* of the diagonal is 42 per cent. of the actual distance between the points. I do not state that the *saving* is 42 per cent., for if the diagonal were opened then the gain by it as compared with the distance formerly traveled would be about 30 per cent., as I have shown in a paper entitled, "The Best Arrangement of City Streets," published in the Franklin Institute Journal, of April, 1877, where I say "the greatest economy in distance will be in passing from the corner to the centre, which route by the square system is equal to L*, and by the diagonal to

$$L\sqrt{\tfrac{1}{2}} \text{ the ratio being } \frac{L\sqrt{\frac{1}{2}}}{L} = \frac{1.4142}{2} = \frac{70}{100}$$

This gives a gain of 30 per cent., which is the greatest amount possible, and from which it diminishes to zero" at the middle point of one side of the square.

I have explained my position thus at length because of the statement in Dr. Chance's paper implying an error in my com-

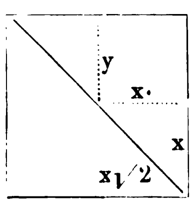
* L being the length of the side of the large square under consideration.

putations, based upon an alleged *saving* of 42 per cent. He says: "It is true that every person traveling in a diagonal course across a rectangular system of streets must lose 42 per cent. of the time actually necessary to accomplish the air line distance, but the saving to such by the opening of a diagonal thoroughfare amounts to but 29 per cent. of the time and distance he formerly traveled."

This statement substantially corroborates all that I have said, so that, whilst in point of fact we are agreed, it is so worded as to mislead a reader into the belief that I have stated that the *saving* was 42 per cent., which is not the case. But admitting that it was as much as 42 per cent., it would not affect the results which I have given, for they are based upon the actual distances saved as taken from the city map, and the figures furnished by the railroad companies of the moving portion of the population.

Speaking of the diagonal, page 119 of Proceedings, I say, it would reduce the distance from 23,000 to 16,000 feet, thus saving 1⅓ miles (or 30 per cent., not 42) for every person required to move diagonally across the heart of the city;" and in another place I add that "by ANY means the distance traveled over by this vast moving population *could* be lessened but one mile, it would effect a saving, etc." (see page 123). I do not wish to be misunderstood as stating that the diagonal *would* save 1⅓ miles to all of the moving population, but only to those persons living on that line and doing business in that direction. Then I proceed to show what the result would be *if* one mile only *could* be saved to the assumed roaming population, and in this estimate I have purposely omitted a very large percentage of the pedestrians.

This saving may also be discussed algebraically as follows:



The distance by the rectangular system from any point to the centre, may be simply represented by $2x + y$, and from the same point *via* the diagonal will be $x\sqrt{2} + y$; the ratio (R) of these distances may then be represented by $R = \frac{2x + y}{2\sqrt{x} + y}$ a function of two variables. The percentage of saving (S)

will be $S = \frac{(2x + y) - (x\sqrt{2} + y)}{2x + y} 100 = \frac{58.6x}{2x + y}$ in which if $y = 0$, we have $S = (1 - .707) 100 = 29.3$ for the distance saved by the diagonal to residents on that line. If $x = 0$, that is if the diagonal be not used, S becomes $\frac{y - y}{y} = \frac{0}{y} = 0$, or nothing saved.

In the expression for R, if $x = 0$, $R = 1$, or the distance traveled must be equal, and if $y = 0$, R will $= 1.42$, or the gain by the diagonal will be 42 per cent. of the air line distance, as previously stated.

2. To obtain his results Dr. Chance assumes an ideal city of 50 blocks on a side, each 340+60 ft. square with only two diagonals. This makes the city 20,000 ft. square, or more than four times the size of that portion of Philadelphia to which I have applied the two diagonals centering at Broad and Market streets, and as the percentage of benefit from a diagonal is inversely proportional to the area of the square whose corners it joins, it is evident that deductions from his special case are not applicable to the one under consideration.

3. In making up his estimate, the Doctor assumes that one-fourth of the resident population will pass to and from the centre of the city *each day*, and computes the distances traversed, first by the rectangular system as = 984,848 miles and then by the opening of diagonals as = 798,912, giving a gain of 185,936 miles per day, which, reduced to one year, the basis in my estimate would give a saving of 66,866,640 miles. And this is the result of saving only 18⅞ per cent. of the original distances by the rectangular system, to the 250,000 roaming population.

He says further, however, that all of the moving population do not have the intersection of diagonals for their objective point, and then *assumes* that only three-fourth of the original one-fourth move in that direction, thus reducing the amount "to 14⅓ per cent. of the total travel, a saving in distance of 2957 feet" for each person.

This supposition would reduce the above 66 and odd millions of miles to 51,328,125, which at the very low estimate of two (2) cents per mile would be a gain of $1,026,562.50, and this is the

result as deduced by Dr. Chance based upon a city in which the ratio of diagonals to area is only about half that of the case under consideration and in which the percentages and the data are all assumed.

It shows the necessity for expressing the results of improvements intended to benefit large masses, in the aggregate rather than the individual amounts and of reasoning from less to greater rather than the reverse.

But Dr. Chance proceeds to state that his 14½ per cent. gain would not be applicable to Philadelphia for four reasons, which are briefly: 1st, that the city has several business centres, and that the direction of travel is not towards the intersection of diagonals, since they do not exist; 2d, that the Pennsylvania avenue diagonal would benefit but a small percentage of the population; 3d, that the Francis street diagonal would likewise be an accomodation to a very small percentage of the traveling public; 4th, as only a limited number of railway companies could use the diagonal streets the benefit to them would be slight.

These points may be briefly answered by stating: 1st, that, in general, the greater the number of diagonals and business centres the larger will be the percentage of population benefited, provided too great an area be not sacrificed to streets; 2d, that the assumption implied in the above objections that the opening of diagonals would produce no change in the directions of travel will not accord with the fact, for travel, like water, will seek the line of least resistance; where the travel is there will the business be gathered together; 3d, the portion of the population benefited by the Francis street diagonal will be independent of the system proposed for Broad and Market streets, and would ultimately become very large; 4th, that travel may proceed on a diagonal in two directions, either convergent or divergent, or both, and that Dr. Chance evidently considers only those persons desiring to reach the centre via Pennsylvania avenue whilst I had in view the removal of the dangerous railroad crossings at grade and the facilitating of travel to and from the park from the southern and southeastern section of the city, and 5th, I do not claim that the benefit to the street cars will amount to much from

reduced distance as their traffic is almost entirely local, yet they would gain from the concentration of travel and business upon certain lines.

In summing up, notwithstanding the *apparently* insignificant results arrived at as expressed by Dr. Chance, he says, "the economy of time and the distances saved * * certainly make diagonal thoroughfares a *desideratum* and in designing city plans these advantages should not be forgotten," and in another paragraph in reply to his query, would they pay? he answers, "yes, financially." His main objection then to such a system seems to be based exclusively upon sanitary considerations, and because the building area would be slightly increased enabling a corresponding increase in density of population he believes they would be injurious to health.

I cannot agree with him in this view of the case, for whilst it may have the effect of slightly increasing the density, it should not be forgotten that it would also open up new and broad avenues of communication, for not only the four but the eight winds of heaven to circulate freely through the city, and that there would be a larger volume of *wholesome* air in circulation than under the present system, provided, the street contractors and others did their duty. Too much air, however, is not always a blessing, for if health is a function of plenty of air, gardens, flowers and sunlight, then a residence surrounded by all of these should certainly be a boon, and of all the homes in this country that of its chief magistrate should be in every respect possessed of these essentials to health and happiness, and apparently it has them all,—parks, trees, grass, flowers, air and sunshine; but do they keep out disease? no, they waft it in from its nest by the river side, and it is now a fact that the lady of the manor lies dangerously ill with malarial fever contracted from breathing poisonous air.

My point is that air to be wholesome must be pure, and that many of the back yards in this city are filled with rubbish, ashes and refuse of all kinds forming just so many disease centres, and that to convert them into street areas would be a gain. Moreover, I do not think the opening of diagonals would sensibly increase the density of population, for most of the space would be occu-

pied by stores having no permanent residents other than janitors or watchmen.

From a sanitary point of view I would also call attention to the fact, that every mile or half mile of distance saved in the heart of a city, is just that much added to its radius, and the gain to the city is an available building area outside of its former periphery, having a length equal to the periphery and a breadth equal to the distance saved. Thus, if by any system of improvements the distance which one travels daily has been reduced from 2 miles to 1½, he may go a half mile further, and probably find larger and more comfortable houses for lower rents, without losing any time or distance as compared with the old system. Thus the individual gains not only financially but physically; the real estate owner gains from increased demand for more property; the city gains from increased assessments and the carrying companies gain from the greater distribution of population. In short it is a gain all around.

As a sanitary measure therefore I believe that the opening of diagonals would be highly beneficial even in Philadelphia, and it seems to me inconsistent to object to them on that ground, and then to admit that a population of 400 persons per square of 340 ft. on a side may be *comfortably* housed in a city where the total population is one million. This would give as I have already shown only 289 square feet to each person, a density greater than that of any ward in the city.

It should also be noted that these diagonals would be north-east and north-west, south-east and south-west, and hence the buildings upon them would receive a more equal distribution of that great disinfectant, the sunlight, than if placed on the meridians or parallels, and in all new cities where the topographical and other considerations will admit it, the rectangular streets should be laid out in these oblique directions and the diagonals on the meridian, thus also avoiding the east and west glare of the sun when he is near the horizon and the absence of shade on the north and south streets at midday.

But Dr. Chance assumes that I have not discussed the subject from a sanitary point of view. Let us see if this assumption is justifiable.

First, we must determine what a sanitary consideration is. I should define it generally to be one which tends to increase longevity. Thus it will include not only the removal of all insalubrious and noxious substances, and the substitution therefor of life-giving elements, but all measures tending to relieve a community from overwork, either mental or physical, or from accident.

It will be seen then that the improvements suggested by me are in a high degree sanitary, as they would cause the removal of piles of refuse and debris, would open up new avenues for the more general circulation of air and diffusion of sun; would reduce the difficulties of reaching the park, that magnificent reservoir of fresh air; would diminish the risks of travel in any direction in and about the city; would enable the people to scatter out into the more rural districts without loss of time and money, and would effect a great saving of time, energy and annoyance, by concentrating business within narrow limits.

The only offset to all these benefits, is the alleged slight increase of density, which would be possible, but which I do not think probable, for the reasons already given.

Only last week, within two days, five persons were either killed or seriously injured, from being struck by trains at grade crossings within four miles of the centre of the city. Two of these accidents were on Willow street, one at Thirteenth, the other at Broad, another, not published, at Ninth and Jefferson.

In closing his comments Dr. Chance says: "The health of a city, other things being equal, will vary inversely as the density of its population. This is true, but unfortunately it can not be applied to any case, for part of this element of health is covered by the expression "other things being equal." Now as they never are equal, and never can be, it is difficult to say just how much disease, etc., is due to increased density. Washington is probably as sparsely settled as any city in this latitude, and is said to have the widest streets of any city in the world. It has been under the care of talented engineers ever since its incorporation, and we would therefore naturally expect to find it the most salubrious place in the East; but unfortunately the statistics show its death rate to be higher than that of our own city, with its cobble

stone pavements, inefficient street-cleaning system, and foul water, chemical experts to the contrary, notwithstanding.

Having given as I believe due weight to the arguments of Dr. Chance, I fail to see that the opening of diagonals will be in any degree detrimental to the health of the city, and will not detain you longer by protracting this discussion.

ABSTRACT OF MINUTES OF MEETINGS.

Of the Club.

March 5th, 1881.—Regular Business Meeting.—Vice-President Henry G. Morris in the chair. Twenty-six members present.

The following amendment to Article XV of the By-Laws was adopted: To strike out the opening sentence and insert in lieu thereof the following: *The annual dues of Resident Members shall be $7.50, and of Non-Resident Members $5.00, payable February 1st, and the initiation fee shall be $5.00.*

A resolution of thanks to Mr. Winthrop Sargent for photographs presented by him to the Club, was passed and the Corresponding Secretary was directed to extend to him the privileges of the rooms of the Club.

Mr. A. R. Roberts tendered his resignation as Treasurer of the Club, and requested that a committee be appointed to audit his accounts. His resignation was accepted, the thanks of the Club returned for his services and his accounts referred to the Finance Committee.

March 19th, 1881.—Regular Meeting.—Vice-President Henry G. Morris called Past President L. M. Haupt to the chair. Twenty-one members and one visitor present.

Col. Wm. Ludlow read a paper entitled, "An Outline Sketch of Modern Military Engineering."

Prof. L. M. Haupt read a paper descriptive of the Deflecting Armor, designed by Mr. N. B. Clark, Past Asst. Engr. U. S. N., for sea-coast defence. The inventor's improvements are based

upon the fact that it is much simpler to resist the effect of a projectile by deflecting it, than by opposing it by thick masses of inert matter, as is evinced by the "ricochetting" of a shot upon the water. He protects all the vital parts of the vessel by an iron shield, convex upward, placed below the water line, and so curved that a shot cannot strike point blank. The guns are mounted upon the back of this shield, but encased in double convex discs, which are practically invulnerable. They are worked by very ingenious but simple devices in the hold, and loaded, swabbed and run into position for firing, by hydraulic pressure. It is claimed that by this means a great economy is effected in the weight of metal required for attack and defence, the vessel is more readily handled, more seaworthy and is invulnerable. The principle may be applied equally well to the construction of batteries for defence on shore.

Mr. H. A. Vezin read a paper upon, "Notes from a Journey in Southern Russia."

April 2d, 1881.—Special Business Meeting. Vice-President Henry G. Morris in the chair. Thirty-four members and two visitors present.

The resignation of Mr. Wilfred Lewis from the office of Recording Secretary was read and accepted.

The following gentlemen were elected Active Members of the Club, viz.: Messrs. M. Van Harlingen, Gouverneur Morris, Edwin Ludlow, John Mechan, Stevenson Constable, John Marston, Geo. A. Wheeler and C. H. Roney.

The following amendments to the By-Laws were proposed:

To Article III, Section 1—In the fourth line, to strike out the word "*age.*"

To Article III, Section 4—By inserting the word "*letter*" before the word "ballot," and erasing the words "*black balls*" and substituting therefor "*negative votes,*" and for the words "*black balled*" substituting the words "*receiving two negative votes;*" so that the Section will read:

"*Election of members shall be by letter ballot, at a business meeting, and, in case of active and corresponding members, two negative votes shall be sufficient to exclude a nominee, and no candidate receiving two*

negative votes shall be eligible for renomination for one year. In case of honorary members a unanimous vote is requisite to elect. In case of non-election no record shall be made."

Papers were read by Dr. H. M. Chance upon, "An Attempt to Extinguish the Kehley Run Colliery Fire," and, "Wear in Wire Ropes," and by Mr. P. H. Baermann upon, "Submerged Supply Main in Otsego Lake, N. Y."

APRIL 16TH, 1881.—Regular Meeting. President Strickland Kneass in the chair. Thirty-one members and one visitor present.

Papers were read by Mr. C. W. Buchholz upon, "The Construction of Iron Railroad Bridges Subjected to Concentrated Loads Under High Speed," and by Mr. Wm. Henry Baldwin upon, "The Sewerage of Memphis After a Trial of One Year."

Mr. Chas. G. Darrach read extracts from the reports of the chemical experts on the present condition of the water supplied to the citizens of Baltimore. This water is supplied from Lake Roland, and when drawn from the taps has such a disagreeable taste and odor as to be useless for domestic purposes. One of the experts found that there was present a volatile nitrogenous substance unknown to chemistry, which he believes to have been the cause of the offensive smell and taste. Whether this organic substance is injurious to health or not, he is unable to say, that being a question for physicians. The other expert thought that, as the water was taken from near the bottom of the reservoir (some 25 or 30 feet below the surface), the water needed air. Mr. Darrach advanced the same theory, and in proof stated that the surface water of Tumbling Run Dam in Schuylkill Co., when visited in 1875, was good, while that drawn from the bottom was very offensive to both taste and smell. The water taken from the Fairmount pool, during winters when the ice remains for any unusual length of time, becomes very disagreeable.

Mr. Strickland Kneass presented to the Club, a set of large views of the machinery for trench excavations of Mr. Howard A. Carson, of Boston, and an explanation of the same was read.

MAY 7TH, 1881.—Business Meeting. Past-President Frederic Graff in the chair. Thirty-one members and two visitors present.

In view of the probable passage of the amendment to the By-Laws providing for the election of members by letter ballot, the election of pending candidates was postponed until the next business meeting.

The amendments to the By-Laws, proposed on April 2d, 1881 (see minutes of that date), were adopted.

The Secretary announced the contribution to the library of a number of books, etc., by Mr. Chas. E. Billin, and they were received with thanks.

The Secretary was instructed to request Past-Presidents L. M. Haupt and Thomas C. Clarke to allow the insertion of their phototypes in the Proceedings.

It was ordered that a copy of the portrait of Past-President Frederic Graff be handsomely framed and hung in the Club room.

The Secretary announced that a prize of one hundred dollars had been offered by a member, who requested that his name should not be made known, for the best contributions to the Proceedings; that it had been accepted by the Board of Directors and divided, at the suggestion of the donor, into two parts, one-half to be awarded for the best mechanical and one-half for the best civil engineering paper, and should include papers read before the Club until the first meeting in April, 1882, and that the result should be announced at the last meeting in June, 1882. (See Rules on page 340.)

Mr. Rudolph Hering, Assistant Engineer of the Philadelphia Survey Department, who recently made an examination of the sewerage works of the principal European cities, gave a general account of his trip. He sketched the gradual development of sanitary works, alluding to the indifference upon the subject in the middle ages, the consequent terrible epidemics, the slow development of the recognition of its importance and to the present difference of opinion as to the proper methods, resulting in a great variety of design in the existing works.

He then described the various general designs in historical order and compared the efficiency of present methods. The same system and ideas will not be applicable to every town. The topography, physical features and the customs of the people may

necessitate radically different plans. Rain water, in some cases, might be led off on the surface; in others, like Philadelphia, it must, to a great extent, be carried away in deep sewers. The "*separate system*," which is common in England and has recently been partially executed for Memphis, is therefore not economical here, except in localities where the present sewers are found entirely unsuitable for the proper conveyance of house water and could be used for storm water alone. When the entire system is built anew "*the combined system*" has been adopted, the best example of which is found in Frankfort on the Main.

Mr. Hering found, compared with American cities in general, that much greater care was given not only to the design and construction, but especially to the maintenance of the sewers. Frequent and thorough inspection was found to be exercised everywhere. A regular system of cleaning was considered as important as the building of the sewers themselves. He walked through hundreds of them and seldom perceived an odor as strong and disagreeable as is frequently noticed on our sidewalks near an inlet. In Paris the "egouts" are frequently visited by strangers, including ladies. In Hamburg, the Crown Prince of Germany took an hours trip through one of the large sewers. Mr. Hering was generally escorted by the chief engineers or the assistants, who think nothing of a walk through their sewers because, as far as the odor is concerned, there is little or no difference than in going into a common cellar.

The cost of city drainage averages about the same as with us. The expense of a regular inspection, cleaning and repairing is little greater than what we pay for repairs alone. Of course, the price of labor is somewhat less, but the municipal engineers, however, are better paid, as a rule, than in the United States. All appointments are permanent, the best fitted are generally selected for office and pensions await any disabled servant of the corps, from the chief down.

There is no small field for improvement in the sewerage of our own city and the experience gained by so many other large cities could be very profitably put to use for our own benefit, not to save money but to get more efficient works for the amount we are spending.

Finally, Mr. Hering gave a brief description of the methods for purifying the sewage before it is discharged into the rivers.

Dr. H. M. Chance presented a discussion of Prof. L. M. Haupt's recent paper on Inter-communications in Cities.

The Club adjourned to meet in business meeting on May 21st, 1881.

May 21st, 1881.—Special Business Meeting. Vice-President Henry G. Morris in the chair. Nineteen members and one visitor present.

The Secretary reported the rules adopted by the Board of Directors for the award of the prize of one hundred dollars. (See page 340.) He also read letters from Past-Presidents Thos. C. Clarke and L. M. Haupt, expressing their willingness to comply with the request of the Club that their portraits might be inserted in the proceedings.

On motion the thanks of the Club were tendered to Mr. M. Richards Mucklé, Jr., who had provided for the distribution of a large number of the last issue of the Proceedings, without expense to the Club.

On motion the Secretary was instructed to hereafter publish the present occupation of candidates for membership, when their names were submitted to vote.

The following gentlemen were elected Active Members of the Club: Messrs. Geo. F. Evans, Geo. S. Strong, Harrison C. Lüders, D. J. Matlack, Jacob H. Yocum, C. W. Macfarlane, L. P. Evans, Graham Spencer, Thos. A. Roberts and Edwin F. Dawson.

On motion it was ordered that, hereafter, the reports of tellers of election should be made in the presence of Club members only, and that such reports should be regarded as confidential among the membership, when negative votes were cast.

A paper on the "Comparative Anatomy of Locomotive Engines," was read by Mr. Geo. Burnham, Jr.

Prof. Haupt replied to Dr. Chance's Discussion of his paper upon Inter-communications in Cities, etc.

Mr. Rudolph Hering exhibited and explained a number of ancient and modern maps of European and Asiatic cities, showing the method of their development.

Mr. Chas. A. Ashburner, of the State Geological Survey, stated that he had adopted the Amsler's Planimeter for the estimation of the mine areas in the survey of the Anthracite Coal Fields of Pennsylvania, and had subjected the accuracy of the instrument to a severe test. In computing areas in square inches of map surface, it was found that the maximum error was one-quarter of one per cent. In computing areas on maps of large scale the average error of the planimeter is believed to be less than either the minimum error of a careful compass survey or of an accurate plot.

On motion the Club adjourned to meet in Business Meeting on the second Saturday of June.

JUNE 4TH, 1881.—Regular Meeting. Vice-President Henry G. Morris in the chair. Eighteen members and two visitors present.

Prof. L. M. Haupt read "Notes on Cobble Stone Pavements." In connection with the consideration of the uncleanliness of this kind of paving, Philadelphia newspaper extracts were read upon the filthy condition of the streets and the objectionable character of the prevailing cobble stone roadways.

Prof. Haupt also read a brief discussion of his former paper on the methods of expressing the Scales of Maps and of determining their relations to each other, so as to avoid ambiguity, giving a simple formula applicable to any case.

Mr. Frederic Graff exhibited an ancient map of Philadelphia, made to show the location of the early hose companies of the city.

A letter, descriptive of the recent sad tragedy in a corps of engineers in Mexico, was read by Prof. Haupt.

JUNE 18TH, 1881.—Special Business Meeting. Past-President Frederic Graff in the chair. Twenty-two members and one visitor present.

The following gentlemen were elected Active Members of the Club: Messrs. Jos. N. DuBarry, Isaac S. Cassin, Edwin F. Smith, J. Simpson Africa, John Gardiner, Harvey M. Geer, William B. Cooper, Mansfield Merriman, Wm. L. Billin and Wm. G. Wilkins.

Col. James Worrall read a paper upon, "The Grand Water-

ways of Pennsylvania." Mr. H. A. Vezin described a new form of pantograph, the arms of which being made of hollow bars and suspended by wires from an upright upon the weight, move very easily and smoothly. He also exhibited a "Winkelprisma," a hand instrument composed of two prisms, by the adjustment of which an angle could be measured and readily laid out. It is especially recommended for laying out curves, by using the angle included in the segment and plumbing to points from which the extremities of the curve are visible

Mr. M. R. Mucklé, Jr., exhibited A. M. Stevenson's adding machine, which is quite portable and convenient for some uses.

JULY 2D, 1881.—Special Business Meeting. Past President Frederic Graff in the chair.

This meeting was called for the purpose of taking appropriate action with regard to the sudden death of Mr. Henry Cartwright, Member of the Club. The following resolution was offered by Mr. Howard Murphy, unanimously adopted and ordered to be printed in Philadelphia newspapers and sent to Mr. Cartwright's family.

Resolved, That the Engineers' Club of Philadelphia, in the sad event of the sudden death of their fellow member, Mr. Henry Cartwright, desire to record their grief at the great loss of a prominent and highly esteemed member which has been sustained by the Club, the profession and the business community and that they tender to his family their heartfelt sympathy.

The Club then adjourned.

OCTOBER 15TH, 1881.—Regular Meeting.—President Strickland Kneass in the chair. Twenty-seven members present.

The Secretary exhibited, on behalf of Mr. J. Milton Titlow, screws which had, for 6¾ years, held together three 2 inch courses of yellow pine planks in the floor of Fairmount Bridge, Philad'a, which planks had been treated in some manner with creosote. The screws in question are much corroded, the original diameter being diminished about ⅓ at the middle of the screw, where the fibre of the iron is distinctly exposed. It seemed, however, to be the universal opinion of the members present, that the corrosion

was due entirely to the presence of water between the planks, and not at all to the creosote oil, which would preserve rather than destroy the iron.

The Secretary exhibited copies of a drawing which had been made by a method giving more economical and better results in many instances than the ordinary blue process. Mr. Frederic Graff stated, in this connection, that the ordinary letter-press was the invention of Watt, and that the original was still in existence.

The Secretary read a detailed description of the moving of the Hotel Pelham, at Tremont and Boylston Sts., Boston, by Mr. Nathaniel J. Bradlee, Architect, of that city, for the purpose of widening Tremont Street. This hotel is built of freestone and brick, 96 and 69 ft. frontage. The Boylston Street wall is supported on 8 granite columns 12 ft. high, 3 and 4 ft. square. There is a basement and 7 stories above the sidewalk. Height above tramways on which it was moved, 96 ft. Weight, 5000 tons, exclusive of furniture, which was not disturbed during removal, as also were not the occupants of the stores on first floor and some of the rooms, the various pipe connections being kept up with flexible tubes. Careful experiments with models showed that if the lower part of the building was firmly braced, there was no danger of shifting in the parts above. The general arrangements consisted of heavy and substantial stone and brick foundations for iron rails and rollers, and the building was forced to its new position by 56 screws, 2 inches diameter, ½ in. pitch, operated by hand against timbers, arranged to uniformly distribute the pressure against the building. Much care and ingenuity was displayed in the details of the arrangements and work. Two months and twenty days were occupied in preparation. The moving itself was begun on August 21st, and finished on August 25th, but the actual time of moving was but 13 hours and 40 minutes. The greatest speed was 2 inches in 4 minutes. The hotel moved about ⅛ inch at each quarter turn of the screws. The whole distance moved was 13 ft. 10 inches. 4351 days labor was required for the work. The whole cost was about $30,000. This is the largest building that has ever been removed, although larger have been raised, which latter is a

much simpler and less risky operation. The complete success of this undertaking is shown by the fact that cracks, which existed in the walls prior to removal, were not changed by the operation. Paper was pasted over them before commencing, that any change might be seen.

President Strickland Kneass exhibited a drawing which had been sent to him by telegraph during his recent visit in Europe.

Prof. L. M. Haupt exhibited a note book, loaned by Mr. John C. Trautwine, containing many complete and beautiful sketches of bridge construction, notably of the celebrated Wernwag Bridge which crossed the Schuylkill at Callowhill Street.

An informal discussion of the necessity and desirability of obtaining better and more extensive quarters for the Club, occupied the remainder of the session.

Of the Board of Directors.

March 12th, 1881.—Special Meeting.

Mr. Howard Murphy was elected Treasurer for the unexpired term of Mr. A. R. Roberts, resigned.

The Treasurer was directed to send bills for full dues to all active members, asking those entitled to non-resident dues to forward claim to that effect.

The salary of the Corresponding Secretary and Treasurer was made payable monthly.

Bills approved, $48.10.

March 19th, 1881.—Regular Meeting.

Bills approved, $28.08.

April 16th, 1881.—Regular Meeting.

Mr. Howard Murphy was elected Recording Secretary for the unexpired term of Mr. Wilfred Lewis, resigned.

Bills approved, $532.99.

May 7th, 1881.—Special Meeting.

Preliminary arrangements for award of prize of one hundred dollars offered by a member of the Club, who desires to remain

unknown as the donor, were made and ordered to be announced to the Club (see Club Minutes, May 7th).

Bills approved, $83.57.

MAY 21ST, 1881.—Regular Meeting.

Rules for award of prize of one hundred dollars were adopted. (See page 340).

Bills approved, $67.55.

JUNE 4TH, 1881.—Special Meeting.

The Secretary was instructed to have printed a revised List of Members and Constitution and By-Laws.

The price of single copies of the Proceedings was fixed at 2 cents per page.

Bills approved, $109.35.

OCTOBER 15TH, 1881.—Regular Meeting.

Action was taken with regard to members in arrears.

The following was ordered to be inserted, hereafter, in the Proceedings: "The Club, as a body, is not responsible for the facts and opinions advanced in its publications."

Bills approved, $394.37.

CONTRIBUTIONS TO THE LIBRARY.

From April 10th to November 4th, 1881.

From the INSTITUTION of CIVIL ENGINEERS.
Mr. James Forrest, Sec'y, London.
Colson and Meyer—Portsmouth Dockyard Extension Works.
am Ende—The Weight and Limiting Dimensions of Girder Bridges.
Brown and Adams—Deep Winning of Coal in South Wales.
Abstracts of Papers in Foreign Transactions and Periodicals. Vol. LXIV. Session 1880–81. Part 2.
Andrews—The Use of Cellular Caissons.
Bell—The Empress Bridge over the Sutlej.
Dawson—The Paroy Reservoir.
Haton de la Goupillière—Explosions of Fire-damp.
Howkins—Scarborough Harbour Improvement.
Hurtzig—The Friction of Timber Piles in Clay.
Kinipple—Portland Cement, Compo and Concrete, at the Garvel Dock Works, Greenock. 2 Copies.
Kühl—Dredging on the Lower Danube.
Lowe—The Protective Works for Preventing the Threatened Outbreak of the South Rangitata River, N. Z.
Rymer—Jones—The Osakayama Tunnel, Japan.
Taylor—The Flow of the River Thames.
Baker—The Actual Lateral Pressure of Earthwork.
Phillips—The Comparative Endurance of Iron and Mild Steel when Exposed to Corrosive Influences.
Marillier—A Bucket Dredger in Use at the Hull Docks.
Thomson—The Tide Guage, Tidal Harmonic Analyser and Tide Predicter.
Airy—Logarithms of the Values of all Vulgar Fractions (with corrections).
Baker—Railway Springs.
Brunton—The Production of Paraffin and Paraffin Oils.
Carrington—Three Systems of Wire Rope Transport.
Higgs—Construction of Electro-Magnets.
Jamieson—The Internal Corrosion of Cast Iron Pipes.
Macalister—Caissons for Dock Entrances.
McDonnell—Repairs and Renewals of Locomotives.
Abstracts of Papers in Foreign Transactions and Periodicals. Vol. LXV. Session 1880–81. Part 3.
Edinger—Brick-and-Concrete, and Concrete Gasholder Tanks.
Murgue—Centrifugal Ventilators for Mines.
Parry, Harrison and Laws—Earthwork Slips.
Target—A New Form of Module for Irrigation Purposes.
Hunter—Wood-working Machinery.
Browne—Tidal and Upland Waters.
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Holley—On Rail Patterns.

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Mell—Auriferous Slate Deposits of the Southern Mining Region.

Manness—A New Bottom for Bessemer Converters.

Moses—On the Applicability of Edison's System of Electric Lighting to Mines.

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Taylor—A Fluxing Gas Producer for Making Heating Gas.

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MR. W. H. BREITHAUPT, Sec'y, Troy, N. Y.
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DR. ISAAC NORRIS, Secretary. Phila.
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From MR. JOHN KENNEDY, Chief Engineer of the Harbour of Montreal.
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From GEN. H. G. WRIGHT, Chief of Engineers, U. S. Army.
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From the Author, MR. G. BOUSCHREN, Cincinnati, Ohio.
Instructions for Laying Out Circular Curves with Spiral Approaches (3 copies).

From the Author MR. P. W. SHEAFER, Mining Engineer, Pottsville, Pa
Sheafer—Geology of Schuylkill County.

From COL. E. PRINCE, Quincy, Ill.
Breaks in Sny Island Levee, July, 1880. 14 Photographs, with key.

From the Author MR. JOHN C. TRAUTWINE, Honorary Member of the Club.
Trautwine's Engineer's Pocket Book, 1881. Bound.

From MR STRICKLAND KNEASS, President of the Club.
Six large views of Norman and Carson's Exca-

vating Apparatus, with explanation of the same.

From COL. JAMES WORRELL, Member of the Club.

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From MR. SAML. L. SMEDLEY, Member of the Club.

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From the Author DR. H. M CHANCE, Member of the Club.

Chance—The Construction of Geological Cross Sections.

Chance—An Analysis of the Fire-damp Explosions in the Anthracite Coal Mines, from 1870 to 1880.

Chance—The Auriferous Gravels of North Carolina. 1881.

From MR. P. H. BAERMANN, Member of the Club.

26th Annual Report of Water Commissioners, City of Troy for 1880.

From the Author, MR. RUSSELL THAYER, Member of the Club

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THE FOLLOWING PUBLICATIONS have been added to the Exchange List of the Club.

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The Sanitary Engineer, New York.

Portefeuille Économique des Machines, Paris.

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The Leffel Mechanical News, Springfield, Ohio.

LIST OF MEMBERS.

ADDITIONS TO JUNE 18TH, 1881.

Active.

Elected May 21st, 1881.

EVANS, GEORGE F., Civil Engineer, U. S. Engineer's Office, 1125 Girard St., Phila.

STRONG, GEORGE S., Mechanical Engineer, care of C. D. Wainwright, 73 Kilby St., Boston, Mass.

LÜDERS, HARRISON C., Metallurgist and Manufacturer, 2216 Spruce St., Phila.

MATLACK, D. J., Foreman of Foundry, Port Richmond Iron Works, 1515 Marshall St., Phila.

YOCUM, JACOB H., Civil and Mining Engineer, 302 State St., Camden, N. J.

MACFARLANE, C. W., Mechanical Engineer, with Wm. Sellers & Co., 1600 Hamilton St., Phila.

EVANS, L. P., Assistant Engineer, Philadelphia Bridge Works, Pottstown, Pa.

SPENCER, GRAHAM, Superintendent American Kaolin Works, Kaolin P. O., Chester Co., Pa.

ROBERTS, THOMAS A., Superintendent Bedford Division Penna. R. R., Bedford, Pa.

DAWSON, EDWIN F., Assistant Engineer U. S. Engineer Department, 1722 Wallace St., Phila.

Elected June 18th, 1881.

DU BARRY, JOSEPH N., Assistant to President Penna. R. R., 233 South Fourth St., Phila.

CASSIN, ISAAC S., Mechanical and Civil Engineer, 1404 North Twelfth St., Phila.

SMITH, EDWIN F., Chief Engineer of Canals, P. & R. R. R., Reading, Pa.

AFRICA, J. SIMPSON, Civil Engineer and Surveyor, 320 Penn St., Huntingdon, Pa.

GARDINER, JOHN, Civil Engineer, Department of Internal Affairs, Harrisburg, Pa.

GEER, HARVEY M., Civil Engineer, Troy, N. Y.

COOPER, WILLIAM B., Civil Engineer, Fort Edward, N. Y.

MERRIMAN, MANSFIELD, Professor of Civil Engineering, Lehigh University, Bethlehem, Pa.

BILLIN, WILLIAM L., Mining Engineer, Poncha Springs, Chaffee Co., Colorado.

WILKINS, WILLIAM G., Civil Engineer, Penna. R. R. Co., 233 South Fourth St., Phila.

NOTE.—A complete revised List of Members will be published, in which all changes and corrections may be seen.

RULES

For the Award of the Prize of $100.00 offered by a Member of the Club, May, 1881.

1.

The prize shall be divided into two prizes of Fifty Dollars each, which shall be awarded for the two papers, one upon a subject in Mechanical and the other in Civil Engineering, which shall be deemed the most deserving in their respective classes.

2.

Competition for either of these prizes shall be confined to original papers, contributed by Active Members of the Club and not, prior to the period of competition, read or printed within the Club or elsewhere.

3.

All papers intended for competition, in common with all other papers read before the Club, shall become the exclusive property of the Club, with the right to publish the same in the Proceedings under the existing rules for the publication of papers.

4.

The Committee of Award shall be elected by the Board of Directors and shall consist of three members of the Club who shall not have contributed papers during the period of competition.

5.

It shall be the duty of the Committee of Award, in determining the successful papers, to accord great weight to careful and thorough investigation and to practical value as compared with theoretical discussion.

6.

Competition shall be limited to all papers read before the Club between and including the first meeting in September, 1881, and the first meeting in April, 1882, and the Committee of Award shall announce their decision at the last meeting in June, 1882.

7.

The prizes shall be awarded in money, but, if the recipients so request, shall be converted by the Committee of Award into such testimonials as the recipients may select and the Board of Directors approve.

USE OF COMPRESSED AIR MOTORS FOR STREET CARS.

Report to the Pneumatic Tramway Engine Co., of N. Y., by General H. HAUPT, C. E., Honorary Member.

Read March 1, 1879, by Prof. L. M. HAUPT, Member.

NEW YORK, February 20th, 1879.

To HENRY HARLEY, ESQ.,

General Agent of the Pneumatic Tramway Engine Company.

Sir:—Candor compels me to acknowledge that I approached the considera-tion of the applicability of compressed air as a motor for street engines with

WE ARE indebted to Gen'l Haupt for the use of the printed sheets of his Report to the Pneumatic Railway Company of New York. This fact will explain the want of uniformity in type and paging with the PROCEEDINGS proper.

Suppose, for the sake of illustration, that there were ten compressors connected with one shaft, and that it was proposed to compress the air to ten atmospheres. There would be ten discharges into the receiver at each revolution, each discharge being one-tenth of a cylinder, and the sum of the whole equal to one full cylinder at the proposed maximum tension.

The power exerted in effecting the compression in each cylinder would be in proportion to the mean pressure throughout the stroke, if the air cut off at one-tenth were allowed to expand, which is 3.302, and if the air was not used expansively the theoretical loss without allowance for friction would be as 3.3 to 1, and with friction fully as 5 to 1.

But the air can be and is used expansively, and the simple device of a fly wheel, by which momentum can be stored up and maintain uniformity during a revolution, secures equally favorable results with a small as with a large number of compressors connected with a shaft, and I see no reason whatever to question the results claimed for the compressors manufactured at the Delamater works, and now used on the Second Avenue Railroad,

of 50 horse power of compressed air, capable of being fully utilized for every 100 horse power expended in the engine which works the compressors.

But it will be said there is still a loss of one-half as compared with steam applied directly. I answer, Not so; and in this fact is found the key to the solution of the problem, and to me it was a most unexpected and satisfactory result.

The minimum of weight is essential in a locomotive engine. Heavy appliances for securing economy of fuel cannot by any possibility be applied to them. Compound and condensing engines are entirely inadmissable on wheels, but all the known economies in engines, regardless of weight, can be introduced in stationary plant, and Corliss, Delamater and others, now secure as an ordinary result, a duty of one horse power from 2½ pounds of coal.

At the Holly Works at Lockport, which claim an exceptionally high average duty, the daily evaporation is nine pounds of water to one pound of coal under 25 pounds pressure, or seven pounds of coal to one cubic foot of water evaporated; and in small boilers, such as are used for heating purposes, the average evaporation under ten pounds pressure is only four pounds of water per one pound of coal, or 15.7 pounds of coal per cubic foot of water evaporated.

One cubic foot of water evaporated per hour is usually taken as a horse-power, but at one atmosphere effective pressure it produces rather less than 33,000 foot-pounds, so that the consumption of these small boilers would be fully 16 pounds per horse-power.

With no very reliable data to determine the consumption of coal and evaporation of water in ordinary street motors, it will, no doubt, be greatly in their favor to credit them with developing a horse-power with ten pounds of coal; and the conclusion therefore is, that although one-half the power of the stationary engine is lost in compressing air, yet the economy of fuel can be made so great that a given amount of power in compressed air is secured at one-half the cost of the direct application of steam to street motors.

But this is not all. By the simple device of heating the air by passing it through a tank of water it is claimed as the result of constant practice in Paris, confirmed by recent experiments on the Second Avenue Railroad, that the capacity for work is doubled, or the gain 100 per cent., making the economy of power as compared with the direct application of steam to street motors, measured as it should be, by coal consumed, four to one in favor of compressed air. I propose to examine whether this claim can be considered theoretically well founded.

Air is compressed into the car reservoirs under a pressure of 350 pounds per square inch, or 24 atmospheres, nearly.

It is not applied directly to the motor cylinders at this pressure, experience having shown that the best practical results are secured at 16 atmospheres, about 240 pounds.

But the air is not applied cold, it is admitted to a tank of water placed on the front platform of the car, containing 5 cubic feet of water, drawn from a stationary boiler, under 80 pounds pressure and having a temperature of 328 degrees.

If air is admitted to the tank at 60°, and leaves it at 328°, the increase of temperature will be (328—60)=268°.

To raise one pound of water from 32° to 212° or 180°, requires as much heat as would raise 4.27 pounds of air through the same range. The specific heat of air as compared with water being as .2377 to 1, one pound of air increases in volume by heat from 12.387 cubic feet at 32° to 19.323 cubic feet at 328°=6.936 cubic feet increase.

The volume of air at 24 atmospheres being 1, the volume at 16 atmospheres would be 1.5. If the volume of air at 32° be 1, the volume at 60° will be 1.061, and at 328°=1.59. It appears, therefore, that in heating a given quantity of dry air to 328°, it will be increased in volume under constant pressure over 50 per cent., and under constant volume the pressure would be increased in the same proportion.

This expansion is due simply to *dry* air; when moisture is present to the point of saturation the pressures are greatly increased.

If air at 30° be taken as unity, dry air at 212° will occupy a volume of 1.375, and saturated air at the same temperature 2.672, or about double.

The expansion of 1000 cubic feet of air, from 0 to 328 degrees, can be determined from the formula:—

$$v = V \times \frac{p+f}{P+F} \times \frac{458.4+t}{458.4+T}$$

In which V, P, T and F are the volume, pressure, temperature and elastic force of vapor, or gas at the original temperature, and v, p, t and f at the increased temperature. Substituting we find

$$v = 1000 \times \frac{32.136+190}{32.136+.044} \times \frac{458.4+328}{458.4+0}$$

$$v = 1000 \times 6.9 \times 1.716 = 11840.$$

Conceding that only a small part of this theoretical expansion can be realized in practice, as the air when expanded in the motor cylinders is cooled very rapidly and there are other losses, there is still a wide margin to justify the claim of double power from heating the air. I admit I was incredulous when I saw it first stated as the result of experiments in Paris and when your very intelligent engineer, Mr. Hardie, assured me positively that the declaration was fully sustained by actual work on the Second Avenue Rail Road, where double runs of 6½ miles had been accomplished with the same expenditure of moist and heated air as single runs of 3¼ miles with dry air; but I am now prepared to credit the assertion and the inevitable conclusion that results therefrom, that the power secured and utilized in air compressed with the best engines and compressors now in use costs, as compared with ordinary steam street motors, only one-fourth as much per horse power measured by the coal actually consumed.

The air is not admitted to the motor cylinder at 350 pounds pressure, but at a much lower pressure, so that after passing the tanks and becoming heated and charged with vapor, it enters the cylinders at 250 pounds, requiring but a comparatively small volume of the dry air from the reservoirs to do the work.

This uniformity of pressure is secured by means of a reducing valve placed in the pipe, which acts automatically until the pressure is reduced below the pressure of admission. When the air has become so far exhausted as to fall below this pressure, the reducing valve remains fully open.

If the water should be cooled down 100 degrees the power of the heated air would be reduced, but would still retain great efficiency.

It can readily be understood therefore that a very important gain results from heating the air, and the economy of the arrangement is so great that it should never be omitted.

REDUCTION OF THE TEMPERATURE OF THE WATER IN RUNNING A GIVEN DISTANCE AND THE COST OF HEATING THE AIR.

Suppose one mile be taken as the distance run. The tank contains 5 cubic feet of water=$62\frac{1}{2} \times 5 = 312$ pounds, and 312 pounds contain a total above zero of $312 \times 328 = 102336$ units.

The motor cylinders are 6½ inches diameter and 13 inches stroke, containing each 431.38 cubic inches, and the two cylinders 862.76 cubic inches.

Allowing 3 per cent. clearance the cubic contents at each revolution of the wheels will be one cubic foot very nearly.

The diameter of the wheels being 28 inches, the number of revolutions in one mile will be $5280 \div (28 \times 3.1416 \div 12) = 720$, and the expenditure of mixed air and vapor will be 720 cubic feet in one mile.

Assuming the work actually done to be doubled by the heat and vapor, one half or 360 cubic feet per mile at atmospheric tension will be estimated as the consumption of dry air. Thirteen cubic feet of dry air at the temperature of 60° and atmospheric pressure weigh one pound, and the specific heat of air being .2377 it will require $13 \div .2377 = 54$ cubic feet of dry air raised one degree to be equivalent to one pound of water, or to absorb one unit of heat for each degree of temperature. As 360 cubic feet of dry air are expended in one mile, $360 \div 54 = 6.6$ heat units required for one degree and to heat 360 cubic feet of air from 60° to an average temperature of 256°=196° will require $196 \times 6.6 = 1294$ units.

But the air does not remain dry in passing through the tank. It has been demonstrated by actual work on the Second Avenue Rail Road that in three trips of 9¾ miles, starting with 350 pounds and finishing with 85 pounds pressure, the water absorbed was 3 inches in a tank of 20 inches in diameter, which is very nearly 4 pounds of air to one pound of water expended. 4 pounds of air$=4 \times 13 = 52$ cubic feet and $360 \div 52 = 7$ pounds of water nearly consumed per mile, and at an average temperature of 256° the number of heat units absorbed per mile in water would be $256 \times 7 = 1792$, and adding the 1294 units required to heat the air, the total units absorbed per mile will be $1792 + 1294 = 3086$. As the tank contained above 212° 36,192 units, $36,192 \div 3086 = 11.7$ miles as the run for which the water should suffice.

It is not claimed that these calculations are rigidly exact, for the amount of vapor condensed in expansion in the cylinders and cooled by radiation it would be difficult to compute, and is unnecessary. As the work is conceded to be doubled by the use of the hot water, it simplifies the problem to assume a half instead of a full cylinder of air to do the work, leaving heat and vapor to supply the balance.

COST OF HEATING THE AIR PER MILE.

To raise 5 cubic feet of water from 212° to 328° requires, as we have seen, 36,192 units, or 1,251 units per mile. Allowing 8,000 units of heat per pound of coal consumed, the coal required to heat the 5 cubic feet of water would be $36,192 \div 8,000 = 4.5$ pounds, at a cost of one cent, and this is less than average duty.

It would seem from the result of this calculation that fully 100 per cent. has been added to the power of the engine and to the miles run, at a cost of one cent in coal for heating the water.

HOW MANY MILES WILL THE PNEUMATIC MOTOR RUN?

The air reservoirs contain 160 cubic feet at 24 atmospheres. The equivalent at one atmosphere is 3840 cubic feet. Allow one-third to be retained as reserve, there will be left to be utilized 2560 cubic feet. But in consequence of vapor and expansion by heat, this quantity is practically equivalent to 5120 cubic feet at the escaping tension. The number of cubic feet of air and vapor expended per mile run has already been ascertained to be 720 cubic feet; and $5120 \div 720 = 7.1$ miles nearly, still leaving a reserve of one-third.

But it has been found that the actual performance exceeds this theoretical limit, and that starting with 350 pounds pressure, 9¾ miles have been run with a reserve of 85 pounds. How can this be accounted for? Simply by the fact that the estimate of 7.1 miles was based on the supposition that a cylinder of mixed air and vapor at atmospheric tension was expended at each stroke. If nearly 50 per cent. more duty was actually secured, it proves that *less* than a cylinder of air and vapor did the work.

But, it may be asked, how is this possible? How can expansion be carried beyond atmospheric tension without creating a vacuum, and losing power by working against back pressure? This question I asked of Mr. Hardie and the explanation brought to light another beautiful feature of this motor. There are valves called suction valves in the exhaust passages, and whenever the tension of air in the cylinder falls below that of the atmosphere, these valves open and permit the stroke to be completed without back pressure, so that it is not necessary to use more air than will overcome the resistances, and this may vary from a full cylinder to a very small fraction, or between limits as extreme as one to thirty.

INCREASED POWER FROM MOTOR CYLINDERS ACTING AS AIR PUMPS.

The motor cylinders are so arranged that in descending steep grades they act as air pumps, and at the same time as brakes, by which means it is found, as stated by the company's engineer, Mr. Hardie, that in running down grade on the Second Avenue Railroad, pumping back against a pressure of 200 pounds in the receiver, the pressure was increased 7 pounds in a distance of .4 mile. As it requires 360 cubic feet, to run one mile, 0.4 miles would require 144 cubic feet.

If the pressure were increased 7 pounds in a receiver containing 160 cubic feet at 200 pounds, the air pumped back would have been 5.3 cubic feet at 200 pounds in 0.4 of a mile, equal to 69 cubic feet at atmospheric tension, which is about half the amount of air that would have been ex-

pended in running an equal distance with the aid of the heat on a level, with a consumption of one cylinder of air at each stroke, but with actual results 50 per cent. greater.

To appreciate the importance of this result it must be observed that not only is all the air saved in running down hill and not a particle used, but half as much or more as would have been expended with the aid of heat and vapor upon a level is pumped back again, and at the same time the action of pumping back acts as a most efficient brake, the efficiency of which is spoken of by the intelligent mechanical engineer of the Delamater works in terms of the highest commendation.

This is certainly a most extraordinary result, and so large a percentage of gain is only possible in consequence of the great expansion in the motor cylinders. The air and vapor escape at the tension of the atmosphere, without the noise which attends the escape of high pressure steam. When the air at atmospheric tension is pumped back again, it can readily be perceived that a certain percentage of the power expended will be restored, since only half a cylinder of air or less is required to do the work at each stroke.

Such a contrivance can only be characterized as admirable, and it will be perceived adds another considerable percentage to the gain in coal as compared with steam motors.

When a locomotive engine shall, while running, be able to manufacture coal and store it in the tender, it will then be able to rival this performance of the pneumatic motor.

It has been shown that at atmospheric tension the contents of the motor cylinders are just one cubic foot for each revolution of the car wheels and that there are 720 revolutions per mile. There should be pumped back therefor 720 cubic feet, if the inclination were steep enough to employ full power, and which I find by computation to be 198 feet per mile; and when heated, saturated and expanded, this air should run the car two miles or more instead of one. In other words, while running down hill one, mile on a grade of 198 feet, the motor theoretically might store up enough to run it two miles on a level; and recent experiments have shown that 50 per cent. may be added to this estimate.

HEAT AND COLD BY COMPRESSION AND EXPANSION.

In some forms of pneumatic apparatus much inconvenience has been experienced from the heat liberated in compression, and again from the intense cold resulting from expansion which deposited ice in the cylinders and ports when moisture was present, as it always is in air in its ordinary condition. It has been stated by writers on pneumatics that one pound

of air at one atmosphere and at 60° compressed to two atmospheres is heated 116°, and the units of heat liberated per pound are $.238 \times 116 = 27.6$ units.

Conversely the expansion of air causes an absorption of heat or productive of cold to a corresponding extent.

The compressors constructed at the Delamater works in New York secure absolute exemption from the inconveniences both of heat and cold. The apparatus now in actual use on the Second Avenue Railroad consists of an engine with two steam cylinders 12 inches diameter and 36 inches stroke, operating two double acting compressors of same stroke, one of which has a diameter of 13 inches and the other a diameter of 6½ inches.

The number of strokes per minute in charging a car are 76 at the commencement and 70 at the end; the difference being caused by the difference in work to be performed.

The fly-wheel weighs about 4 tons with a diameter of about 10 feet.

The air cylinders are jacketed, and a current of cold water circulates around them continually.

The air compressed in the first compressor to about 5 atmospheres, passes into a tank of water in which the water is kept cold, and from thence into the second compressor, where it is reduced in volume one-fifth a second time, making one-twenty-fifth of its original volume.

The water tanks perform a most important office, not only in cooling the air, but strange as it may seem, in drying it also.

The explanation of this apparent inconsistency is simple:

Ordinary atmospheric air contains more or less water, which on reduction of temperature below the dew point, is deposited to a certain extent on cold surfaces.

In compressing 25 cubic feet of air into one, and cooling it with water it is estimated that twenty-four parts out of twenty-five of the water will be absorbed and removed.

When this dry air is again expanded by being utilized in the motor, it cannot deposit ice, because there is no contained water to form ice, and hence the fact, which it is said has excited great surprise amongst observers, that no frost whatever was formed except on the outside of the pipes from condensation of outside moisture.

Mr. Hardie stated that when the pressure ran low and the temperature of the tanks fell below, about 100° frost began to be formed. This is precisely as should be expected. If air, in being compressed to one-half its volume, liberates 116 degrees of heat, it must absorb an equal amount in

expanding, and if the water has cooled so low as not to furnish sufficient heat to compensate for it, the moisture taken from the water tank must form frost to some extent.

It was observed by Mr. G. H. Reynolds, of the Delamater Works, that the heat liberated in proportion to the power secured was much less at high than at low pressures. The fact had not previously been brought to my attention, but I think a satisfactory explanation can be given. Imagine a vessel containing one pound of air at ordinary tension 13 cubic feet, the base 1 square foot and height 13 feet. If, by means of a piston, this air should be forced into one-half the space, or 6½ feet, the pressure would be increased to 30 pounds, and the work done would be 21.528 foot pounds. One pound of water raised 1° is equivalent to 772 foot pounds, and as the specific heat of air is .238, $772 \times .238 = 184$, the foot pounds expended in heating 1 pound of air 1°. Then $21{,}528 \div 184 = 116°$ = the heat liberated in compressing one pound of air into half its volume.

Now suppose the 6½ cubic feet of air should be again compressed one-half, or to 3¼, the final pressure would be 60 pounds, and the space 3¼ feet and the work 21.528 foot-pounds as before, representing 116° of heat. But with these 116° of heat the pressure has been increased from 2 atmospheres to 4, and in like manner from 4 to 8, from 8 to 16, and from 16 to 32, would each require but 116°, and at the end 16 atmospheres of additional pressure have liberated only as much heat as one atmosphere at the commencement. Assuming that the heat when liberated has been absorbed so as to secure isothermal contraction of volume.

This consideration, with others, induces Mr. Reynolds to favor the use of much higher pressures, running up to at least 500 pounds; in this way double the power could be secured with an increase of weight only in the receivers. There are at present practical objections to this increased pressure, as mechanical difficulties prevent the proper utilization of pressure over 250 pounds, and all the extra power expended in compression would be lost. The only benefit would be in securing additional reservoir capacity. If these mechanical difficulties can hereafter be overcome, the use of pressures of 500 pounds would be a great advantage, and there would be no trouble in making the receivers sufficiently strong to carry it.

In the admirable system of water works machinery designed by Mr. Holly, of Lockport, steam admitted to one cylinder and there expanded is exhausted into and re-expanded in three others, securing great economy. If, instead of being of the same size, one large and one small motor cylinder were employed, and the air from the small cylinder exhausted into the water tank at the proper tension, say 125 pounds, to be moistened and

heated and then sent to the larger cylinder at 250 pounds, possibly some such plan would permit the use of air at 500 pounds, in which, I fully agree with Mr. Reynolds, there would be great advantage; and I would here venture another suggestion in regard to future possibilities of compressed air. Why can it not be compressed to high tensions by cheap power, transmitted for considerable distances through pipes, and used expansively in compound engines with heater, without the annoyance and risk of large boilers and coal consumption on the premises where the power is utilized? There is no reason to apprehend danger from this increase of pressure. The air receivers, unlike steam boilers, never deteriorate; the air being perfectly dry, and the receivers coated internally, there can be no rust; and if pressure is increased, the thickness of material can be increased also, and the factor of safety remain the same. Any defect of material or work would be revealed by proper tests, and if a rupture should occur, there would be only an escape of cold air—no steam and no fragments of iron. A cylinder, fully charged, was ruptured in France purposely by the fall of a heavy weight. The air escaped simply with a hissing sound; no fragments were projected as in explosions of steam boilers, and cold, not heat, resulted from the expansion.

WHAT GRADES CAN THE PNEUMATIC MOTOR OVERCOME, AND WHAT LOAD CAN IT CARRY?

These are pertinent questions and can be readily answered. Ordinary locomotives are so proportioned in their boiler and cylinder capacity as to be able to slip their wheels on a dry rail if the engine should be chained fast, so that it could not advance upon the track.

In that case the adhesion which is, at a maximum, about one-fifth of the weight upon the drivers, measures the power of the engine and not the pressure in the cylinders. The power varies and is greatly reduced in bad conditions of the track.

Power of Motor Cylinders. Assumed that the air is used under 16 atmospheres, cutoff at one-sixteenth and expanded to fill a cylinder at atmospheric tension, giving mean pressure .236. The initial pressure being 16 atmospheres the mean pressure is $16 \times .236 = 3.776$ atmospheres and $3.776 \times 15 = 56.64$ pounds per square inch. The diameter being $6\frac{1}{2}$ inches, the area is 33.18 and the piston pressure $33.18 \times 56.64 = 1879$ pounds. If the air should be cut off at $\frac{1}{8}$, instead of $\frac{1}{16}$, the mean pressure would be 6.158, and the crank pressure 3064.

There are 2 cylinders, cranks at right angles, one at full stroke when the other is on its centre. The weight of the car loaded is 8 tons. There

are four wheels connected. Weight on drivers 16000, adhesion one-fifth= 3200 pounds. The radius of the wheel is 14 inches, and of the crank 6½ inches, then $3200 \times \frac{14}{6.5} = 6880$ pounds to be exerted on the crank, not allowing for friction of machinery, if it be required to slip the wheels on a dry rail. Or, stated in other terms, the power of 1879 pounds at the crank is equivalent to 871 at the rail, and 3064 at crank to 1422 at rail.

The power of the motor cylinders with ordinary consumption of air is therefore insufficient to slip the wheels on a dry rail, but with street motors so large an amount of cylinder power as would be required for that purpose is unnecessary, owing to the frequent bad condition of the track, a large surplus of adhesion is required. The cylinder power can be increased fourfold by admitting a full cylinder of air, but this would be objectionable, as causing waste of air and noise from exhaust.

With a small motor of 6 tons the adhesion would be reduced to 2400 lbs., and the crank pressure required to slip the wheels to 5160 lbs. The adhesion in ordinary conditions of the rail is therefore, as it should be, in excess of the cylinder power, and the wheels can slip only in consequence of ice and snow. It remains to determine the power for propulsion on a straight and level track and the power required on grades.

The traction of ordinary railroad trains is 9.2 pounds per ton on a straight and level road, based on the regular business of the Pennsylvania Railroad, but with a street motor it is said to require about 25 pounds per ton, eight tons require 200 pounds, and this resistance acting on a lever of 14 inches from the axle, while the propelling power acts with 6½ inches, will increase the power on the crank to $200 \times \frac{14}{6.5} = 430$ pounds.

As the power on the crank with the 8 ton motor is 1879 lbs., it would be sufficient to move 4 such cars or 32 tons on a straight and level road, not allowing for friction of machinery and losses in transmission of power from the crank, if, as has been stated, the traction does not exceed 25 pounds per ton, upon which this estimate is based. It is found that, when dry air is used and the machinery is cold, the pressure of the air by gauge indications being 20 lbs., it required the full head to propel the car, while, where warm air was used, the car moved when the gauge indicated considerably less pressure.

Twenty pounds pressure is 1⅓ atmospheres. The average mean working pressure is 3.776 atmospheres. Twenty pounds produces 625 lbs. crank pressure, or 300 at rail, and, if this amount was required to overcome friction and move the motor, it would be equivalent to 37½ pounds per ton instead of 25 pounds, and absorb 50 per cent. more power than has been allowed, but it is stated that there was a back pressure at the time of several pounds per square inch, in consequence of the small size of the

exhaust ports, which would cover a considerable part of this difference. It is possible, therefore, that, with the air heated, the traction may not exceed 25 pounds per ton, but it would be well to test both the traction the motors and of ordinary cars by a dynamometer.

GRADES.

It has been shown that if air is admitted into the working cylinder at a pressure of 16 atmospheres, cut off at one-sixteenth of the stroke and expanded to atmospheric tension, the mean pressure on the crank would be 1879 pounds and the equivalent to overcome resistance at the rail 871 pounds, capable of moving on a straight and level road, if all could be utilized, 4 cars of 8 tons with traction of 25 pounds per ton, and certainly 2 cars.

Also if the air should be cut off at ⅛ the mean crank pressure would be 3064 pounds and the equivalent at the rail 1422 pounds, capable of moving 4 such cars upon a level. As the angle of friction with traction of 25 lbs. per ton is 66 feet to the mile, the eight ton motor should be able to haul twice its own weight on a grade of 66 feet or 2 cars, on a grade of 132 feet 1 car, but 2 cars could be hauled by increasing the amount of air and cutting off say one-sixth instead of one-eighth.

The eight ton motor without extra cars attached should be able to overcome the steepest grades usually found on horse railroads. The steepest grade on the Second Avenue Railroad is said to be 230 feet to the mile or one in twenty-three. The power with a full cylinder of air would be about 8 times the average power expended in working, and consequenily the reserve is large enough to overcome great resistances of limited duration.

SMALL MOTORS OF 5 TONS WITH CARS ATTACHED.

It would be a most serious disadvantage if the general introduction of pneumatic motors should require the abandonment of the old plant. Fortunately such abandonment is not only unnecessary, but the best possible system for the economical operation of a line and for the accommodation of the public consists in the use of small cars and coupling 2 or 3 in a train under one conductor, at hours when the travel requires it.

Suburban residents desire frequently to make social visits or to attend lectures or places of amusement in the neighboring cities, and can testify to the discomfort, not to say danger, of riding home late at night with one foot on the platform and the other in space.

The ordinary horse car, loaded, weighs about five tons, the motor would weigh about the same, or with six tons would admit a large increase of cylinder capacity ; there would then be no pretext for objection on the

ground of injury to track. It could run with one car in the middle of the day, and morning and evening with 2 or 3 under one conductor. It could make the trip in half the time, certainly in two-thirds, of the horse car and take the place of 15 horses, the sale of which would pay for the motor, so that there would be no expenditure whatever for street motors, and nothing except for engines and compressors at the station.

The small motors weighing six tons would have the same cylinder power as the 8 ton motors previously described, which gives 871 or 1422 pounds at the rail, as the air is cut off at $\frac{1}{16}$ or $\frac{1}{8}$ of the stroke. The adhesion with dry rail is 2500 lbs. and the traction of the motor at 25 lbs. per ton $6 \times 25 = 150$ pounds.

If these small motors should be used to haul ordinary horse cars it becomes necessary, in estimating the performance of the motor, to know the traction of such cars. For obvious reasons this traction must be less per ton than that of the motor and yet more than that of ordinary railroad cars, which is nine pounds per ton. Probably 15 pounds per ton would be a full allowance for the traction of ordinary horse railroad cars, and a train of one 6 ton motor and two ordinary cars of 5 tons, each loaded, would make the weight of the train 16 tons and the traction 300 pounds, an average for the train 18.8 pounds per ton. And 18.8 pounds per ton traction would give the angle of friction at which the train would descend by gravity=44½ feet to the mile.

The train of one small motor and two cars could ascend grades of 178 feet to the mile, and with one car grades of 240 feet to the mile, and steeper grades could be overcome by using more air.*

The separate motor, not intended to carry passengers, except perhaps on top, would permit an increase of reservoir capacity from 160 to 225 cubic feet; and if reservoirs be placed also under the seats of each car the capacity of a two car train with motor would be extended to 325 cubic feet or doubled, and the run to 12 miles. If, in addition, in speculating upon the possibilities of the future, the reservoir pressure should be increased to 500 pounds, instead of 350, the run would be extended 43 per cent. or 17 miles, and with one car attached to motor instead of two, still further. For working elevated railroads as a substitute for steam, the Pneumatic Motor is the perfection of a propelling power. The motor itself could be filled with air reservoirs, giving, with the addition of reservoirs under the seats of the cars, unlimited capacity, and there is no run within suburban limits that would be beyond the power of the motor, with a single station

*Since the above was written further experiments have shown that the increased consumption of air by attaching horse cars to the motor is about the amount that could be supplied by reservoirs under the seats, and consequently that the distance run need not be diminished by attaching additional cars if so provided.

in the middle of the road to reinforce the pressure. The cost of fuel would be reduced fully 66 per cent., and noise, dust, steam and sparks from motor avoided.

If a motor should run off the track, it has power to run itself on the street pavements and can be readily replaced by the aid of crow-bars. If the machinery should become deranged, another motor could push it and by a simple hose attachment, the air in the disabled engine could work the machinery of the helper.

THEORETICAL TEST OF COMPRESSORS.

It is claimed that 50 horse power for 100 horse power of compressors can be actually utilized from the air when compressed. This will be tested.

There are two steam cylinders at the Second Avenue compressor, each 12 inches diameter and 3 feet stroke. The first compresses air to one-fifth or 5 atmospheres, and the second cylinder to one-fifth again, or to 25 atmospheres, and the second cylinder is one-fourth the area of the first.

In compressing to one-fifth, the mean pressure is .522 of initial and the resistance in first compressor is $5 \times .522 = 2.61$ atmospheres throughout the stroke. The resistance in the second compressor is $25 \times .522 = 13.05$, and as the area is $\frac{1}{4}$ of the first compressor the comparative work is $13.05 \div 4 = 3.26$ atmospheres, and $3.26 + 2.61 \div 2 =$ average pressure in both $= 2.94$ atmospheres. The steam pressure 80 pounds $= 5.33$ atmospheres must be cut off at about $\frac{3}{5}$ of the stroke to balance resistance of compressors, omitting friction for the present.

The air is compressed at each stroke to 25 atmospheres in a six inch cylinder, if pumping into a tank under that pressure.

An expenditure of 3 feet steam in one cylinder at 2.61, and 3 feet steam in second cylinder at 3.26 atmospheres, is equivalent to

$$3 \times 2.61 = 7.83$$
$$3 \times 3.26 = 9.78 = 17.61 \text{ atmospheres 1 foot.}$$

The air in the first cylinder was compressed into 1-5, and in the second into one-fifth more of an area $= \frac{1}{4}$. So the result will stand—

$$3 \text{ ft.} \times \tfrac{1}{5} = \tfrac{3}{5} \text{ and } \tfrac{3}{5} \times \tfrac{3}{5} = \tfrac{9}{25},$$

and $\frac{9}{25}$ with $\frac{1}{4}$ area $= \frac{9}{25} \times \frac{1}{4} = \frac{9}{100}$ at 25 atmospheres, $\frac{9}{100} \times 25 = 2.25$ atmospheres, one foot as a basis of computation.

Cut off at $\frac{1}{25}$ the mean pressure is .169, and expanded to atmospheric tension the work done by the air under tension of 25 atmospheres is $2\frac{1}{4} \times .169 \times 25 = 9.5$, as compared to the work in compressing it, which is 17.61, or .54 per cent. of the power expended, omitting friction.

It does not seem possible therefore, with the plans now used, to get quite as much as 50 per cent. from the compressed air when friction is considered and when the air is pumped into a tank, as this calculation supposes, against a resisting pressure of 25 atmospheres, but if the air should be pumped into the car reservoirs directly where the pressure at the commencement would be comparatively low, and the percentage of useful effect greater, it can readily be conceived that the claim of fifty per cent. duty may be fully sustained, particularly as the pistons move with great ease and the air compressors are self-lubricating.

EFFECT OF INCREASING COMPRESSION TO FIFTY ATMOSPHERES.

In compressing air from one to twenty-five atmospheres the heat liberated has been 534 degrees, but in reducing the volume again to one half, the additional heat evolved would be only 116°. In compressing air from 25 to 50 atmospheres the mean pressure would be 42 atmospheres, and if the stroke should be 3 feet, the work done in compression would be represented by $3 \times 42 = 126$. Omitting friction and thermal considerations, if this air were compressed by the direct action of steam upon a piston the pressure being say 5 atmospheres, the area of the piston must be ten times the area of the piston of the compressors, and a full cylinder of steam would be required to overcome the maximum resistance of the air under 50 atmospheres, and the work would be $50 \times 3 = 150$ in the steam cylinder to secure an amount of work represented by 126 in the compressor and which would also represent the amount of work done in the subsequent expansion. But with a double acting compressor and fly wheel the power required would not greatly exceed the mean pressure during the stroke, and the loss would be but little more than that which was due to friction, and therefore the percentage of useful effect would be greater at high than at low pressures, provided it could be as fully utilized in expanding. If expanded without work to the tension required for the ordinary cylinder pressure there would be a great loss of power and the only benefit that would then result from the increased pressure would be reduced reservoir capacity for a given run, or an increased run with a given capacity.

CAPACITY OF COMPRESSORS AT SECOND AVENUE STATION.

The compressor at Second Avenue station is rated at 100 horse power. It developes 66 horse power at mean pressure of steam and 73 strokes per minute. The smaller cylinder is 6x36. Its cubic contents, six tenths cubic feet, and its average of 73 strokes will deliver 44 cubic feet per minute at 5, and about 9 at 25 atmospheres.

A car containing 160 cubic feet, one-third full, will require 106 cubic feet at 25 atmospheres; but as the engine will pump against 8 atmospheres at the commencement instead of 25, the car reservoirs will fill more rapidly at first and the average time should be 7 minutes or, allowing for attaching and detaching, 9 minutes, which is said to have been the exact time required.

To charge one car per minute would require a plant of 500 horse power, which can be furnished at a cost of $20,000; but if trains of three cars are run at intervals of three minutes a smaller sum will suffice for engines, compressors and boilers.

Considering the fact that trains on elevated railroads stop only at stations comparatively far apart, while surface roads may stop at every crossing, the average passenger will be much better accommodated with the pneumatic motor on surface roads than with the elevated railroads, and the difference in time will be trifling.

Where these motors are introduced elevated railroads will never be constructed. The wants of the public for rapid, cheap and convenient transit will be met in the best manner possible by the surface roads now existing.

TO REMOVE ICE AND SNOW FROM THE TRACK ON STEEP GRADES.

The only real objection to street motors, and this applies equally to those propelled by steam and air, is that on very steep grades covered with ice and snow, the adhesion may be so much reduced that the motor cannot be operated.

A remedy suggests itself. A car may be placed in front of the motor containing cylinders with water under 80 pounds pressure, or 380° of temperature to be used in melting and running off the ice and snow.

The heat required to melt ice or snow will raise an equal weight of water from 32° to 140°=108°. 108 heat units are therefore required to melt one pound of ice. Tanks containing 160 cubic feet of water at a temperature of 328° degrees will hold 328×625×160=3,280,000 heat units, capable of melting 3,280,000÷108=30,000 pounds of ice.

Suppose the snow and ice were of such depth as to be equivalent when melted to one inch of water, 8 feet wide. One lineal foot would contain 42 pounds, and 30,000 pounds would require 700 feet of track, which is the distance cleared by water of one car.

The cost of coal for these 700 feet of track at 8,000 heat units per pound of coal, and coal at $4.00 per ton would be 410 pounds coal at $4.00 per ton=81 cents. This would probably be the cheapest possible way of melting down and removing ice and snow from tracks. There should be drains of tile or metal under the tracks on steep grades with

frequent grated openings to allow the water to run off into the sewers and escape before again congealing.

I have assumed that the whole track, 8 feet wide, is to be cleared, but this is unnecessary for the purpose of securing adhesion; one foot wide at the rails might be sufficient.

It might be preferred to construct cars specially provided with tanks for this purpose. This is immaterial, but the weight must not exceed the power of the motor on steep grades, unless, which is very probable, it may be deemed expedient to construct a machine specially adapted to this purpose and hauled by horses to clear tracks in advance, an arrangement, the utility of which is well worthy the consideration of all horse railway companies. The hot water should be discharged under pressure in the form of spray, and to furnish this pressure, when the temperature falls to 212°, a receiver of compressed air should be provided to be turned on when, and as required.

Practically all the heat units could not be utilized, but it might be possible, with 160 cubic feet of water to clear 400 or 500 feet of track at a cost for fuel of 16 to 20 cents per 100 feet.

Possibly it may be found advantageous to combine the hot water with the shovel, or snow-plow. To shovel off the bulk of snow and melt the ice which adheres to the rails and destroys adhesion. A car of water in this way would clear a very considerable length of track. In extreme cold weather a thin film of ice may form on the rail. For this I see no remedy better than the ordinary sand box of the locomotive.

These are crude suggestions, given for what they may be worth, but I have endeavored to anticipate and meet every possible objection to the motor. I can see none except the want of adhesion in winter on steep grades, which applies in common to all other motors, and even to horse-cars, preventing the proper action of the brakes, but, if every other plan fails, there is one resource that never can fail, the shovel, and this must be used even with horse power and very frequently in severe winters. The extraordinary saving in cost of motive power will greatly overbalance any difference in disadvantage caused by the winter obstructions of ice and snow.

The officers of the Company have submitted what I regard as an exceedingly modest estimate of the cost of power as compared with horses, in which it is stated as 2 to 1 in favor of compressed air. If, as has been claimed elsewhere, ordinary steam motors save one-half the cost of power over horses, and if my figures are reliable, showing in consumption of coal more than 3 to 1 in favor of compressed air as compared with ordinary

steam motors, then it would follow that the cost for power alone would be 6 to 1 in favor of air as compared with horses.

Do not misunderstand me, I refer to power alone; general, office and other expenses are unaffected; but power is by far the most serious. The estimate was, moreover, made on dry air before the heater had been added, which so largely increases the percentage saved.

A few minor points in favor of the motor will be stated. Skilled engineers are not required to run them, a man of ordinary intelligence can learn to run these motors in a single trip. What is a most remarkable and beautiful feature of the contrivance is that a driver, however ignorant or careless he may be, cannot fail to use exactly the proper amount of air for the resistance to be overcome. and cannot waste it. If he admits too little, the car slackens speed or stops; if too much, he must shut off the braek. All is done by the movement of a lever, back or forward, no other brake is needed and the motion of the car is a perfect governor.

This arrangement, amongst the many beautiful mechanical devices of the motor, impressed me as one of the most remarkable. I was apprehensive at first that very skillful drivers would be required to prevent a wasteful expenditure of air. I now perceive that a careless driver could not waste it if he would, unless by risking his neck by running at high speed down steep inclines. Another advantage of the motors is that the view of the track is unobstructed and can be seen from the platform on which the driver sits, while horses obstruct the view of the track for 30 feet.

On a level track the car can be stopped within its length when running at a speed of 12 miles per hour, and on grades in a time longer or shorter in proportion. The brake can never be out of order so long as the car has the ability to move at all. The brake consists in a full or partial reversion by moving a lever.

If the lever should get out of order, which is scarcely within the bounds of possibility the car could not move at all, therefore the brake cannot fail. I noticed also in running along the Second Avenue Railroad on the motor that horses on the opposite track meeting the motor would sometimes shy, bu other horses not on the track did not notice it. The car horses would, no doubt, soon become accustomed to the motor, but as its general use would supersede horses altogether, this fact is of little consequence.

OBJECTIONS.

I have been shown a criticism of the motor made by a mechanical engineer of some prominence, which surprises me greatly and can only be ac-

counted for on the supposition that the letter which recites the objections was written without consideration.

I am thankful, however, to have objections stated, when they can be shown to be groundless they serve to inspire and increase confidence.

The objections were:

1. The air car requires 50 horse power to keep it in operation.

True! but if dry air be used the same engine will charge 7 cars per hour, and if moist and heated air be used 14 cars, if the run should not be increased and only half the air should be required, which is only 4 horse power to a car, and each horse power costs in coal consumed one fourth to one third as much as in a street-motor.

Second Objection. The cost of repairs for the steam cars would be less than for the air car.

Ans. No reasons are given and the fallacy of the assertion is self-evident. There is no fire box to burn out and no boiler to rust, burn out or explode. The reservoirs filled with air, absolutely dry, are as nearly imperishable as anything on this mundane sphere can be. The parts liable to wear by friction are the same as on other engines, neither more nor less expensive to repair, but the heaviest expenses of fire box, boilers and flues are all saved.

Third Objection. The air car is not so reliable as a steam car, as it has not the same surplus for emergencies.

Ans. Why not? A surplus is provided of 33 per cent. Does a locomotive finish its trip with as much reserve power in coal and water in its tender? Besides all the cars of a train can have air cylinders under the seats, the whole of which can be held in reserve.

The above are the only objections that I have heard advanced. If there is any force in them I cannot perceive it.

THE MORAL AND SANITARY INFLUENCES OF THE PNEUMATIC MOTOR.

A claim that the pneumatic motor can improve the morals and promote the health of a great city, may provoke a smile, but incredulity may yield to conviction under the logic of facts.

Quite recently a prominent citizen of New York, noted for his efforts in the interests of humanity, invited a number of the clergymen of that city to meet at his house to consider the terrible and increasing evils of the tenement-house system, and devise, if possible, some plan for its amelioration, and it was decided that all who were present should on a day agreed upon, preach a sermon on the subject.

The following startling statistics were given: In a population of one million inhabitants, in New York, one-half, or 500,000, live in tenement-houses, sometimes four families in a room, the boundaries defined by chalk lines. The Seventeenth Ward averages 305 inhabitants to the acre. The Eleventh Ward, 356 to the acre, and some blocks, 750 to the acre. The deaths last year were 27,000, which is 25 per cent. more in proportion to population than in Philadelphia, where separate houses are occupied by separate families, and the tenement-house system does not exist.

The average of cases of sickness to one death is 28, or 750,000 cases of sickness of some kind in New York annually. Of the deaths, 70 per cent. occurred in the tenement houses, leaving 30 per cent. for the balance of the population of equal number.

The deaths in tenement houses were therefore 133 per cent. greater than in the balance of the population. These houses furnish nearly all the paupers and criminals, and a majority of the voters. Their occupants hold the balance of power, control the elections, elect city officials and impose taxes on property owners, while contributing nothing themselves to the burdens they impose on others. These tenement houses are the very sinks of iniquity, hot beds of vice and immorality, the abodes of impurity, and the birth places of pestilence. What is the remedy for these terrible evils? The answer is, separate households and suburban dwellings. Give this population and others, similarly situated, pure air, green fields and Heaven's sunshine, and the evils will be greatly mitigated if not radically cured.

How is this to be obtained? how can laboring men living 3 to 10 miles from a city get to their work and return to their homes at an expenditure of time and money within their moderate resources? The answer is, cheap and rapid transit. A motor whose speed is limited only by considerations of safety, and whose cost for power will not exceed one-third of the cost of steam is the best solution of this most difficult problem. The key to this solution is the pneumatic motor.

Respectfully submitted,

H. HAUPT, Consulting Engineer,
328 Walnut St., Phila.

Or, at Office of the Pneumatic Tramway Engine Company,
17 Broad Street, New York.

Estimate of the cost of Power by the use of the Pneumatic Motor as compared with Horses.

From the reports of sixteen horse car companies in the city of New York, operating 102 miles of road with 1,297 cars and 10,301 horses, it appears that the expenses for 1876 were :—

For repairs of harness,	$41,861	per horse,	$ 4.06
" shoeing horses,	234,578	"	22.77
" feed,	1,281,316	"	124.39
" stable expenses,	434,014	"	42.13
" replacing horses,	227,693	"	22.10
	$2,219,463		$215.45

Cost of one horse one month, $18.00; number of horses to one car average 8.

From the Report of the Second Avenue Railroad Company for 1878 :

Number of cars, 167; number of horses, 1197. Cost of cars $92,800, average cost of one car, $556.00.*

EXPENSES OF RUNNING.

Repairs of cars and harness, - - - . -	$ 30,319
Horse shoeing, - - - - - - - - -	16,593
Horses, - - - - - - - - - - - -	42,000
Stable expenses, - - - - - - - - -	46,542
Feed, - - - - - - - - - - - - -	108,785
	$244,239

Average expenses per horse,	$204.
One horse, one month,	17.
Average horses per car,	10.

ADDITIONAL ITEMS.

The cost of horses, harness, wagons, etc., was $116,600, the interest and depreciation of which will be taken at 15 per cent., in addition to horses replaced=$17,490. 167 cars cost $92,000, the repairs on which

*It is stated by officers of the company that the cars reported (167) include many not in regu-use, the actual number in use is about 105. Horses to one car—10. Cost of car when new, $1050

have been included, but an allowance must be made for interest and depreciation not covered by repairs say, 10 per cent., making - $9,200

Pay of conductors and drivers, - - - - -	$167,335
The total expenses of all kinds were, - - -	$730,466
The total number of passengers carried, - -	16,062,560
The cost per passenger, - - - - - - - -	4.55 cents
Which includes a six per cent. dividend of - - -	$72,000
Cost per passenger exclusive of dividend, - - - -	4.10 cents

SUMMARY.

Expenses as above, - - - - - - - -	$244,239
Interest and depreciation in horses, etc., - - -	17,490
" " in cars, " - - - - -	9,200
Conductors and drivers, - - - - - -	167,335
Interest on stable property, - - - - - -	24,150
Total running expenses with horse power,	$462,414
Running expenses per passenger, exclusive of dividends and general expenses, - - - - - - -	2.88 cts
Including general expenses, - - - - -	4.10 "
Including dividends as above, - - - - -	4.55 "

COST OF OPERATING THE SECOND AVENUE RAILROAD WITH PNEUMATIC MOTORS.

It will be assumed as the basis for this comparative estimate that short motors will be used, each motor carrying two cars and making trips in two-thirds of the time required with horses. The expense of conductors and drivers, which amounts to $1,000 per car, will be reduced one-half.

The motors required for 167 cars* will be 84, at a cost of $1,500 each, $126,000. The interest, repairs and depreciation, 20 per cent.=$25,000.

If the distance between termini be taken at 8 miles and the time one hour, the intervals between trains will be under 1½ minutes, and the cost of compressor plant will be estimated for each station at $20,000. Interest and repairs on which, 20 per cent., $4,000.

It has been shown that the compressor at the Harlem station, which develops 66 horse power while working, charges a motor in 7 min-

* If, as is now stated, the actual number of cars is 105 instead of 167, the motors required will be 53 instead of 84, and motor expenses will be reduced 25 per cent. This will reduce the cost per passenger on sixteen millions carried to 0.67 cents for motive power expenses as against 2.88 cents, with horse power.

utes, or at the rate of 9 per hour, and at the same rate the power required to charge one motor in 1½ minutes would be 380, and at 3 pounds of coal per horse power per hour, the consumption for average of 16 hours would be 1140 pounds per hour and 18,240 pounds or 9.12 tons per day.

The Delamater and Corliss works both claim a duty of 2½ pounds of coal per horse power on the engines constructed by them, but in this estimate 3 pounds have been allowed, and manufacturers have proposed to furnish engines and compressors capable of charging one car per minute for $20,000. The present motor runs 10 miles, but with the increased reservoir capacity of motors not carrying passengers the run should be increased to 13 miles, and one station in the middle should run the road.

To remove all questions, however, as to the sufficiency of the estimate now submitted, two stations will be allowed instead of one; each costing $20,000, and the coal consumption will be increased to 12 tons. The estimate will then stand as compared with horse power:—

Interest and repairs on 167 cars, costing $92,000, at 20 per cent. per annum,	$19,400
Interest and repairs on compressor plant, costing $40,000 @ 20 per ct.,	8,000
Interest on building for compressors,	5,000
84 drivers and conductors, $1,000 per car,	84,000
4 engineers at $ 3.00 per day, 4 assistants at 2.00 " 8 firemen at 2.00 " 12 tons coal at 41.00 " per year,	27,010
Total motor expenses,	$143,410
Cost per passenger for running expenses,	0.89 cts.
Other expenses as before, including a six per cent. dividend, $730,046—$462,414,	267,632
Total expenses including dividends,	$411,042
Cost per passenger on 16,000,000, with dividend,	2.57 cts.
Cost per passenger exclusive of dividend,	2.12 cts.
Maximum capacity of 167 cars all seated and,—assuming all passengers as through,	20,000,000
The comparison of running expenses above stated with horse power per passenger,	2.88 cts.
With pneumatic motor,	0.89 "

And a very slight increase in the number of passengers would permit charges to be reduced to 2½ cents, and still pay 6 per cent. dividends.

CONSEQUENCES.

The estimate herewith submitted, which is believed to be full and liberal, would seem to justify conclusions of great practical importance to stockholders of surface roads and to the public generally. The Second Avenue Rail Road has been taken as an illustration only because the data were accessible. The same results would no doubt follow a comparative estimate on other roads.

On the basis of sixteen millions of passengers carried on this road, operated by horse power, the actual results were:

Running expenses per passenger, inclusive of dividends and general expenses,	2.88	cents.
Estimate by use of pneumatic motor,	0.89	"
Cost per passenger by horse power, including general expenses, but not dividends,	4.10	"
Estimate of use of pneumatic motor,	2.12	"
Cost per passenger, by horse power, including both general expenses and dividend,	4.55	"
Estimate by use of pneumatic motor,	2.57	"

What is the lesson which is taught by these figures? If on the basis of the actual business of the Second Avenue Rail Road the economy of operation can be so greatly increased by the use of the pneumatic motor, that dividends can be paid on a charge of 2½ cents per passenger from City Hall to Harlem, a distance of 8 miles, who can calculate the increase from greatly reduced fares coupled with accelerated speed?

The elevated rail roads have been a complete success. Horse rail roads and stages are doomed; their patronage is rapidly departing, but the compressed air motor comes forward opportunely to save surface roads from ruin, retain their efficiency, usefulness and dividend earning capacity, utilize existing roads, plant and employes and secure a change of system almost without any expenditure of capital, since the sale of horses and harness will generally pay for the motors that supersede them.

If the Second Avenue Rail Road Company would put the fare through from City Hall to Harlem at 5 cents or half the Elevated Railroad charge, and run the 8 miles with compressed air in 40 minutes, a speed entirely practicable if street obstructions are not too numerous, the bulk of the population would

patronize the surface roads, but if these improvements are not adopted it is too clear to admit of controversy, that horse rail roads must succumb. A successful competition with Elevated Railroads is with horse power obviously impossible.

Respectfully submitted,

H. HAUPT, Consulting Engineer,

328 Walnut Street, Philadelphia.

Or, at Office of the Pneumtic Tramway Engine Co,

No. 17 Broad Street, New York.

SUPPLEMENT.

For several days previous to March 12th, 1879, experiments were made with the Motor on the Second Avenue Railroad, the results of which it is proper to note.

March 9th, started from depot at 127th street, and made three round trips, with the following record:—

1st trip started with pressure,	360	pounds
Consumed,	95	"
Returned with	265	"
2d trip started with	265	"
Consumed	95	"
Returned with	170	"
3d trip started with	170	"
Consumed	75	"
Returned with	95	"

This result was so remarkable, that the President of the Company, Mr. F. Henriques, requested the writer to superintend some further experiments, to ascertain if increased duty would be secured by running at reduced pressures. Accordingly, on March 10th, three more trips were made with the following record:—

1st trip started with,	360	pounds
Temperature of water,	324°	
Mean working pressure while running,	120	pounds
Water absorbed,	31	"
Pressure on return,	290	"
Consumed,	70	
2d trip started with,	286	pounds
Mean working pressure,	120	"
Consumed water,	11.3	
Temperature of water on return,	198°	
Pressure at end of trip,	195	pounds
Consumed,	91	"

3d trip started with,	- - - - - - - -	195 pounds
Mean working pressure until pressure fell below,		120 "
Water absorbed,	- - - - - - -	19.8 "
Temperature on return,	- - - - - -	180°
Pressure at end of trip,	- - - - - -	95 pounds
Consumed,	- - - - - - - -	100 "

The comparison of these two tests exhibit very remarkable results.

The total consumption of air in the three round trips was precisely the same, starting with 360 pounds and finishing with 95, consuming 265 pounds or an average of 88.33 each trip. The last trip of the first series was run with 75 pounds. This fact it is difficult to explain, as the water was certainly much cooler than at the start, and it could not have contributed so large a proportion of vapor.

In the first run of the second series the air consumed was 70 pounds pressure, equivalent to 747 cubic feet, or 57½ pounds at atmospheric tension, and this air absorbed the very extraordinary amount of 31 pounds of water, or more than half a pound of water for each pound of air, which is double the average consumption and four times the capacity of ordinary air for moisture.

It will be observed, also, that a great reduction of temperature from 324° to 190° or 126° was found in the two runs.

The large quantity of vapor and heat abstracted from the water in the first run will fully and satisfactorily account for the small quantity of air consumed and would serve to indicate the possibility of increasing the distance run by burning gas or petroleum, to replace the heat which the air absorbs. There must, however, always be a loss of power when air, after being compressed, is expanded to a lower tension without work.

In the last run of the second series 100 pounds were consumed. This was to have been expected, as the water at the end of the run was 32° below the boiling point.

On Tuesday, March 11th, further experiments were made to determine the effect of attaching additional cars to the motor. The following is the record taken by Mr. Harley:—

1st trip started from 127 street, with	- - - -	300 pounds
At depot, 97th street, air pressure,	- - -	250 "
Consumed in half trip,	- - - -	50 "
Coupled on 2 ordinary street cars, pressure at end of trip, 127th street,	- - - -	170 "
Consumed with the 2 cars and motor,	- - -	80 "
Temperature of water,	- - - - -	205°

2d trip, started with - - - - - - - -	335 pounds
Run at mean pressure, - - - - - -	150 "
Cars in tow, - - - - - - - - -	2
Pressure at 97th street, - - - - - -	275 pounds
Consumed, - - - - - - - - -	60 "
Water used, - - - - -	14.2 "
Reduced pressure in heater to - - - - -	130 "
2d trip return, 2 cars in tow, started 97th street, pressure,	275 pounds
Pressure at 127th street, - - - - -	190 "
Consumed pressure, - - - - - -	85 "
Water used, - - - - - - -	14.2 "
3d trip, heated water again, 2 cars started from 127th street with a pressure of - - - - -	330 pounds
At 97th street, pressure, - - - - -	265 "
Consumed, - - - - - - - - -	65 "
Water used, - - - - - - - -	16 "
Return, no cars in tow, started from 97th street	250 "
At 127th street, - - - - - - - -	200 "
Consumed, - - - - - - - -	50 "
Water used, - - - - - - - - -	11 "

OBSERVATIONS.

It appears that the two *up* trips consumed 80 and 85 pounds of pressure, and the two *down* trips 60 and 65 pounds, and the up trips required 33 per cent. more than the down trips. This may be due to the very bad condition of the up track. The average round trip required 145 pounds with two cars attached to motor, as against 90 pounds with motor alone, an increase of 60 per cent. or 30 per cent. for each car hauled. The two cars probably weighed as much as the moter, and if so, the traction of the cars would be 15 pounds per ton, assuming the motor at 25.

The data furnished by observations on the motor will serve to indicate the loss of power and of work in transmission from the piston to the rail, starting at 350 pounds pressure, the run of 9¾ miles was made with 270 pounds pressure, or 90 pounds per average run, or 298 cubic feet of air at atmospheric density per mile. Assuming for the present that the effect of heating and moistening the air is chiefly to compensate for the reduced temperature in expanding, and to secure the full benefit of isothermal expansion, the foot-pounds of work per mile will be computed on this basis.

The volume required per mile to fill the capacity of the working cylinders is 720 cubic feet. The 298 cubic feet therefore filling 40 per cent. of the cylinder capacity, leaving 60 per cent. to be replaced by air from the exhaust passages, by the opening of the suction valves.

If used under an average pressure of 170 pounds=11.33 atmosphere indicated, or 12.33 atmospheres actual, the atmospheric pressure would be reached in $13 \times .4 = 5.2$ inches of stroke in cylinders, and the mean piston pressure during the 5.2 inch stroke would be 1732 pounds.

As there are 4 cylinder discharges to each revolution and 720 revolutions to a mile, the travel of piston per mile run under pressure will be $720 \times 4 \times 5.2 = 14976$ inches=1250 feet and $1250 \times 1732 = 2{,}165{,}000$ foot pounds of work done at piston, per mile of actual run. If now it requires a tractive force of 25 pounds per ton on a level road to move the motor and the weight be 8 tons, then $8 \times 25 \times 5280 = 1.056.000$ foot pounds per mile, which, if the road was level, would represent the actual work utilized from an expenditure of 2.165.000 foot pounds upon the piston, which is 50 per cent. nearly.

It would appear, therefore, that only half the power applied to the piston is actually utilized in propulsion on the track, and the balance must be expended in overcoming friction of motor and other resistances and losses. The power required to move the motor if applied externally, and also the traction of the ordinary horse cars is not known and should be determined.

The computation of average run has been based on an expansion of twelve and reaching atmospheric tension at .4 of the length of the cylinder, using only one thirtieth part of a cylinder of air at each stroke. If a full cylinder of air should be used the power on the piston would be increased nearly nine times, but the consumption of air thirty times.

This great reserve of power over the average for ordinary work is an advantage of no small importance. The reserve of power can be drawn upon to overcome great resistances, if of short duration.

As an illustration of this fact, and since the above paragraph was written, Mr. James states that on one occasion the motor got off the track at a sharp curve and switch at the 127th Street depot; a ditch had been dug for gas pipes and filled in but not paved. The hind wheels sunk in the ditch until the frame of the motor rested on the pavement. A high presusre was let on and the machine pulled itself out without further assistance.

The writer cannot close this report without an acknowledgement of the valuable information that he has received from the Company's

engineers, Messrs. Hardie and James, whose remarkable ingenuity and mechanical skill have secured the results detailed in this report. Mr. James is not only an accomplished machinist, but an expert mathematician, a Bachelor of Science and a graduate of the University of Edinburg.

Mr. Reynolds, the engineer of the Delamater works, is too well and too favorably known too require endorsement from any one. The Pneumatic Tramway Engine Company have certainly been fortunate in securing an unusual combination of talent in their mechanical engineer department, and to this the success of the motor must be largely attributed.

H. HAUPT,

Consulting Engineer.

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